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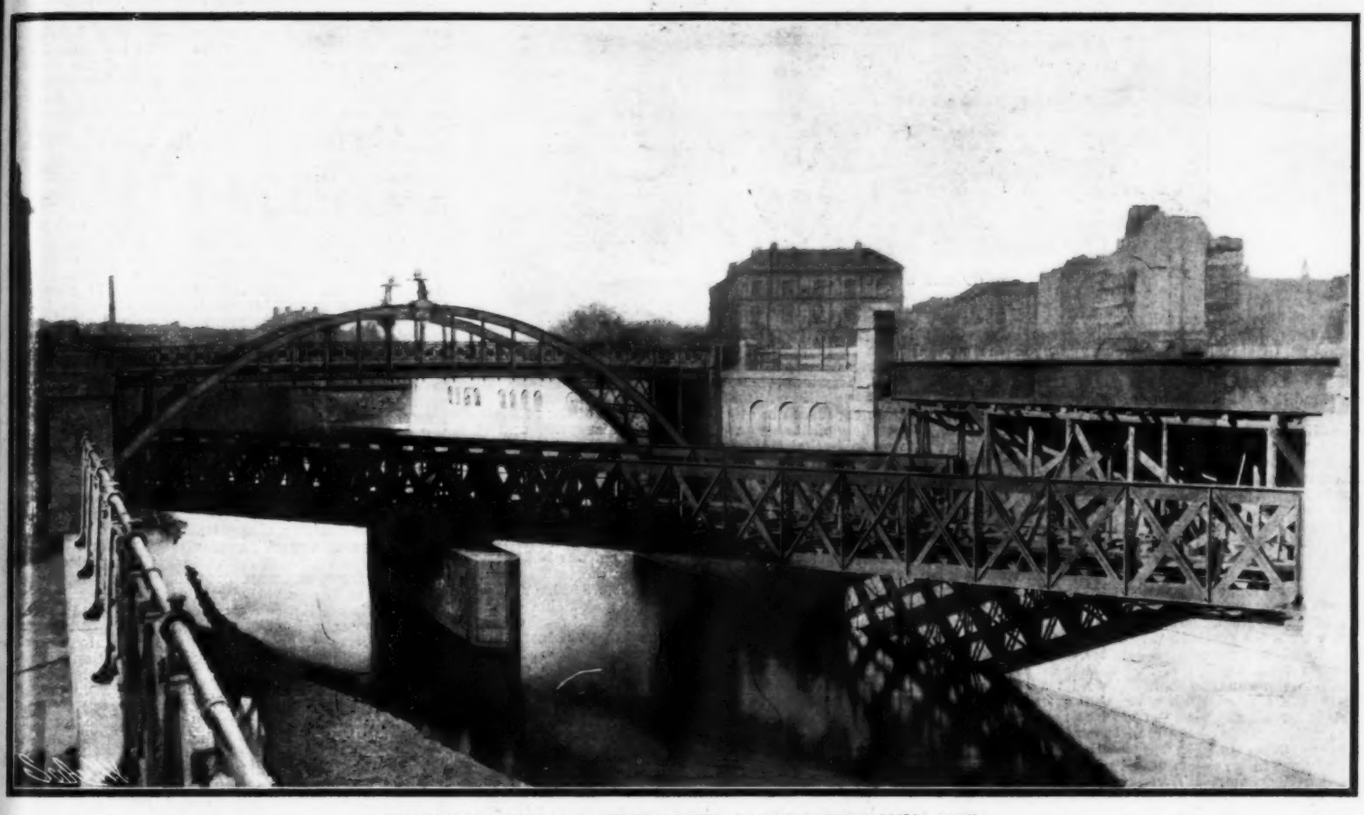
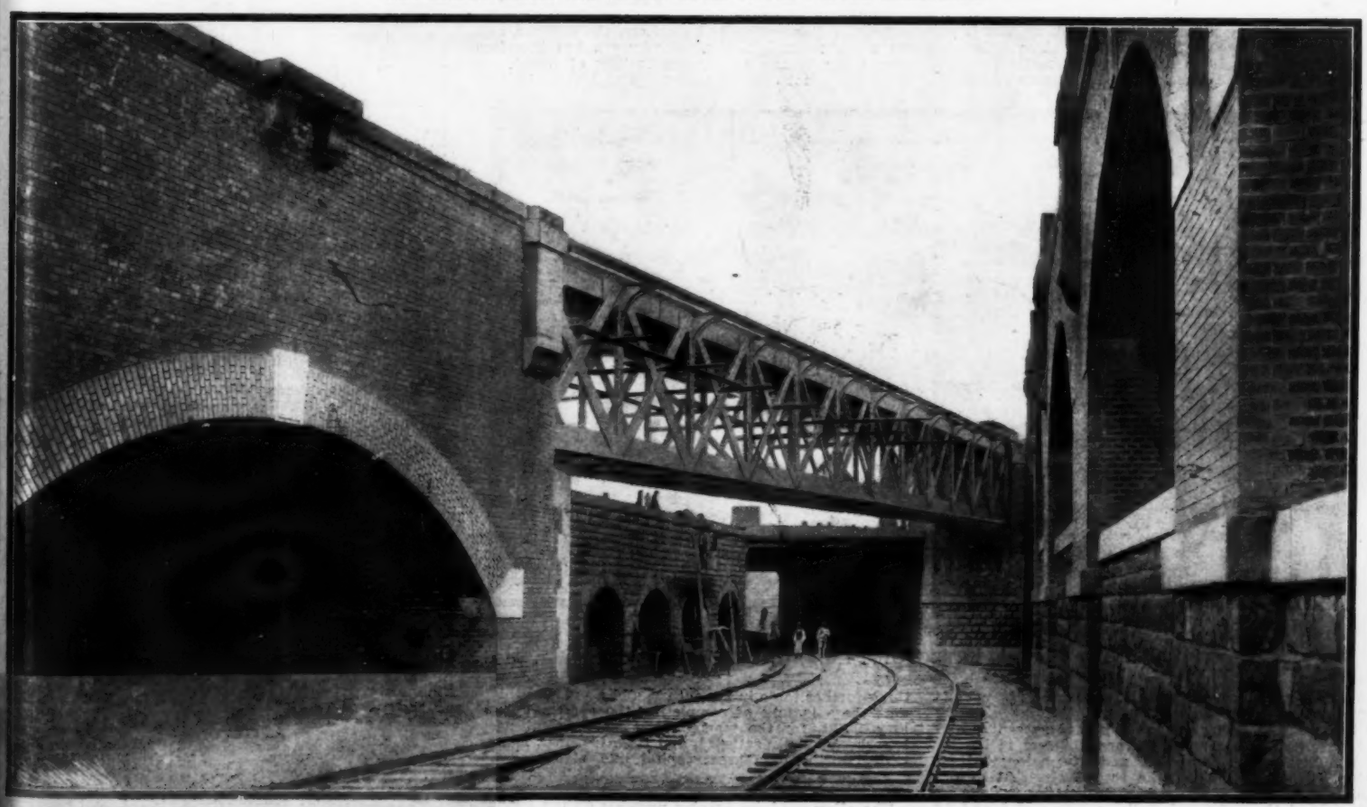


THE BRIDGE ACROSS THE VIENNA RIVER OF THE DANUBE CANAL LINE.



THE DANUBE CANAL LINE CROSSING THE VIENNA CONNECTING LINE.

THE VIENNA METROPOLITAN RAILWAY.

[Concluded from SUPPLEMENT No. 1456, page 23321.]

THE VIENNA METROPOLITAN RAILWAY.*

By EMILE GUARINI.

THE stations open for passenger service are, independently of the two large main stations—Hütteldorf and Heiligenstadt and the central custom house—those of Gerotkof, Hernals, and Ottakring. At the stations, as well as at the stopping places, there are as many platforms as there are directions to be taken; thus, at Heiligenstadt there are five platforms, and at Hütteldorf, six. These platforms are connected by transverse passages, which are generally subterranean. The stations may be divided into two groups according as the line passes through a cutting or runs upon the surface. In the first case the station proper for the service is established above the main tracks, and, in the second, lateral structures of a much more substantial appearance are provided.

ONE OF THE SWITCHES.

The dimensions of the metallic bridges that had to be constructed are nothing more than ordinary. That of Heiligenstadterstrasse is 183.35 feet; that of Richthausenstrasse 278.8 feet in three spans; that of the Francis-Joseph station, 262.4 feet in two spans; that of the Danube line, 131 feet, and that over the Vienna, 377 feet in two spans.

The roadbed for the track has a normal width of 27 feet on the principal lines and of 26 on the secondary ones. The general and detailed arrangement of the bridges calls for no special remark. The masonry viaducts are formed of a succession of arches, the spans of which vary from 19.6 to 49 feet.

As regards the track itself, the ties are of wood and 16 in number per rail. The latter, which is of the American type, is 41 feet in length and weighs 26.4 pounds to the running foot. The rails are connected by means of a special fish plate, the upper flat part of which is on a level with the head of the rail.

The rolling stock of the road consists of 109 locomotives and 861 cars. The locomotives were designed with a view to quick starting and prompt gaining of headway. Their weight, under load, is 69 tons, 43 of which is adhesive weight. The speed that can be attained in one minute is 24 miles an hour upon gradients of 2 per cent. The boiler has a working pressure of 191.1 pounds to the square inch. The fire box is provided with a Marck smoke consumer. The total heating surface is 1,547 square feet. The firing is done with hard coal or coke. An automatic vacuum brake acts upon the wheels with a pressure of 39.027 pounds for a pressure in the pipe line of 9½ pounds per square inch.

Some of the cars used are combined passenger and baggage. All the cars, which are 32.8 feet in length, communicate with each other and have a longitudinal aisle. There are 147 of the second class, 54 of the third, and 174 of the mixed. The heating is done by steam and the lighting by oil-gas lamps of 5 and 12 candle power.

The frequency with which the trains are run rendered necessary the adoption of the block system. The blocks do not exceed 2,600 feet, and the Siemens & Halske system, with electrically controlled switches and signals, is the one used. All the signal tower operator has to do is to turn a commutator. The current actuates a small electric motor, which in turn actuates the mechanism. As long as a block is occupied, the entrance signal to that block cannot be lowered. The train itself lowers the signal by making connection with an insulated rail as it passes out of the block. In case of a failure of the mechanism to operate, the signal will remain set. The source of energy is a 120-volt storage capable of furnishing 0.2 kilowatt-hour per motor, per 24 hours.

The short distance traffic is by far the heaviest, and comprises scarcely any but passengers of a single class. The long distance traffic is especially large on Sundays, holidays, and in vacation time.

The expenses are at present in excess of the receipts, but the deficit has a tendency to disappear, and it is probable that this year an equilibrium will be nearly realized. However, if we take into consideration the indirect benefit that the state and city derive from the installation of the system, it may be said that the sacrifices made have not been in vain, and, indeed, that they are not out of proportion to the results obtained. According to the last statistics, the total number of passengers carried upon the local system was 28,215,436, say an increase of five per cent over the traffic of the preceding year. Of this number, 23,279,936, or 93.04 per cent, of the passengers did not go outside of the system, while 1,909,900, or 6.96 per cent, reached the great lines by means of the branches. An inspection of the figures in detail shows the preponderant influence of the lines that traverse the densely populated quarters.

The commercial speed varies from 11.71 to 18.63 miles an hour. The average is 13.59 miles, or practically the same as upon the other metropolitan lines in operation.

The number of train-miles is increasing very rapidly, and at the time of the last statistics, was 778,757. The ton-miles have undergone the same progression, and have risen from 187,449 the first year to 2,525,267.

Since the inauguration of the metropolitan, a greater and greater traffic has been daily developing between the different central quarters, the suburbs, and the neighboring localities. A new era has therefore opened for Vienna as regards facility of travel. It is evidently not claimed that there will never be anything further to do in the future, and a proof of this is that there is talk of completing the system by new lines. But, for the moment, the most urgent needs have been largely satisfied, and that, too, in a manner really worthy of a great capital like Vienna.

THE BRIDGE ACROSS THE VIENNA RIVER.

THE VIENNA METROPOLITAN RAILWAY.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

The alloy used for bearing purposes on the Pennsylvania Railroad consists of lead and antimony in the proportions of 87 per cent of the former and 13 per cent of the latter.

ALCOHOL AS A MOTIVE POWER.*

THE idea of moving a machine by causing the explosion of a suitable body behind a piston, seems to have been anterior to the plan of employing the expansive force of steam for the same purpose. It is in fact expressed in the writings of the Abbé Hautefeuille and of Huyghens about 1680, who proposed gunpowder as an explosive. Afterward an explosion machine was proposed by the introducer of lighting gas, Philippe Lebon, of Humbertin. This kind of machine continued to attract the attention of engineers, but inventors, weary of the employment of gas, proposed as detonating compounds all sorts of mixtures of air and other substances, the powder of lycopodium and vapors of certain hydrocarbides, even of hydrogen. It was only in 1860 that the first gas motor, really practical, made its appearance. The employment of petroleum in the explosion motor working an automobile vehicle occurred about the same time.

From that period until our own time, numerous improvements have been introduced in the gas motor, but among the models proposed one only has been adopted, that of the four cycles. This has been more or less modified for a better utilization of the expansion, and more or less improved in the construction and adjustment. The power of this class of motors has also been increased. They have been constructed with a cylinder of 500 horse power and with twin cylinders of 1 000 horse power and beyond, but lighting gas, which is too dear, has given place to the employment of poor gases of gas generators, and the needs of agricultural mechanics and of automobilism have led to the increasing employment of petroleum.

It was an American engineer, Brayton, who first solved the problem of the industrial petroleum motor of certain power. From the petroleum two principal products for the motor industry are drawn: (1) lamp petroleum, kerosene, or photogene; (2) gasoline. On passing a current of air through either of these liquids, a detonating mixture is obtained similar to the mixture of air and lighting gas, sufficient for feeding the motors. We have noticed before that for lighting and heating numerous attempts have been made to utilize alcohol during the same period as the experiments with petroleum. The case is the same with reference to the production of motive force, particularly in automobiles, and if in the recent attempt of the Minister of Agriculture in testing the question, an average speed of 80 kilometers an hour has been realized, we do not forget that in April, 1899, a small two-seated vehicle only attained 20 kilometers an hour. The intervening period has, therefore, been sufficient to secure an important improvement in the construction and working of alcohol motors.

In every machine designed for utilizing alcohol as a motive force, we must consider, on one hand, the generator of the explosive mixture or carbureter; on the other hand, the converter of energy, or the motor properly so called.

Carbureters.—These may be divided into several classes; bubbling carbureters for evaporation on the surface (Petreano, Delahaye, Henriod, Dupleix, etc.)

2. Carbureters spraying the liquid in a current of air (Longuemare, Martha, Dion-Bouton, etc.).

3. Distributing carbureters, in which the quantity of liquid is distributed dosimetrically (Gobron-Brillié and Villain).

4. M. Wallut has exhibited a petroleum motor of the Hornsby system, worked with alcohol. If there were a possibility of utilizing present petroleum motors without any modification, it would be quite advantageous, considering the great number of petroleum motors now in use in agriculture.

The heating of carbureters is important, for the temperature must rise to about 100 deg. C. if all the liquid is to be vaporized. A classification may be based on this principle:

1. Heating by conductibility. The heat lost by the exit gases is utilized either directly (Petreano, Martha) or by derivation (Longuemare, Dion-Bouton, Le Blon, G. Richard). In the systems of Dupleix and of Koerting, the waste heat is employed for lighting the lamp.

2. Heating by a mixture of hot air (Delahaye, Gobron-Brillié).

3. Without heating.

Motors.—No specific motor has yet been successfully studied for the explosive mixture of air and the vapor of alcohol, but the gasoline or petroleum motors in use have been employed.

1. Fixed Motors.—Various experiments have been made since 1894. At first alcohol appeared to be quite inferior to petroleum. According to M. Levy, 1 kilogramme of alcohol, yielding 5,600 calories, furnished 3.23 horse power, and 1 kilogramme of petroleum, yielding 9,500 calories, furnished 6.75 horse power; that is, double. M. Ringelmann has summarized similar conclusions in the following table:

	Consumption per hour. Mineral Oil.	Alcohol.	Ratio.
Vertical Motor.	Per Horse Power.		
Empty	1.104 l.	2.267 l.	2.05
Half charged	0.950 l.	1.767 l.	1.86
Full charged	0.892 l.	1.396 l.	1.56
Horizontal motor.			
Empty	0.328 l.	0.771 l.	2.35
Half charged	0.619 l.	1.097 l.	1.66
Full charged	0.407 l.	0.703 l.	1.87

Since the first experiments we have those of MM. Petreano, Chauveau, Delahaye, Gobron-Brillié, who have exhibited various motors. The question has also been considered in Germany, and M. Oelkers has formulated the following results:

	Consumption per H. P.	Price, unit.	Price, H. P.
Carbureted alcohol (85 p.c.)	0.47 l.	0.24 f.	0.11 f.
Gasoline	0.35 l.	0.40 f.	0.16 f.
Petroleum	0.40 l.	0.31 f.	0.12 f.

The comparative figures relating to different methods

* From the French of M. O. Bondouard, Doctor of Sciences, in the Revue de Chimie Industrielle.

of production of explosive mixtures have also been given.

Per effective H. P.	10 H. P.	20 H. P.	30 H. P.
Petroleum	0.128	0.119	0.116
Lighting gas	0.131	0.122	0.118
Poor gas	0.145	0.110	0.097
Gasoline	0.180	0.177	0.176
Alcohol	0.202	0.194	0.190
Acetylene	0.292	0.281	0.277

2. Automobiles.—Since the expansion of the industry of automobile vehicles, the study of alcohol motors has exercised the sagacity of numerous investigators, and since 1899 we have had each year a competition of alcohol motors.

In the Paris-Chantilly contest, 136 kilometers were passed over in 8 hours, 8 minutes with the consumption of 38 liters of ordinary alcohol, or 0.3 liter per kilometer.

In the Paris-Rouen competition, 127 kilometers, out of 48 contestants, 40 completed the course within the time designated. The following figures give the results:

Time.	Consumption.	
2 h. 50 m.	17. liters of carbureted alcohol	(45 per cent.)
5 h. 41 m.	9.0 liters of carbureted alcohol	(40 per cent.)
3 h. 12 m.	25.46 liters of alcohol	(100 per cent.)
4 h. 05 m.	6.25 liters of alcohol	(100 per cent.)
5 h. 08 m.	17.06 liters of alcohol	(100 per cent.)

Paris-Roubaix: 279 kilometers were passed over, either in one stage or in two stages; forty-six vehicles reached Roubaix, of which 6 made use of pure alcohol; 32, carbureted alcohol 50 p. c.; and 8, carbureted alcohol 75 p. c. The consumption varied from 0.076 liter to 0.156 liter, according to the model of the vehicle and the nature of the alcohol employed. The yield with carbureted alcohol 50 p. c. was the best; then came that of pure alcohol, and finally that of carbureted alcohol 75 p. c.

Northern Circuit (alcohol), Paris, Arris, Saint Germain; 924 kilometers. These and other tests show that the employment of alcohol does not present any serious difficulties, but with present apparatus the employment of alcohol is not attended with such facility and good results as gasoline.

Conclusions.—If a reliable comparison between petroleum and alcohol were to be made, it would be necessary to separate it entirely from personal interest.

Theoretically, 1.8 times more alcohol is required than gasoline. The first tests seemed to correspond to this, but the average figures recently obtained indicate only the ratio 1.25. Some engineers, partisans of petroleum, insist that in consequence of the water contained in the alcohol employed and the water formed by the combustion of alcohol, there is a waste of heat. Experiments of M. Loreau have demonstrated incontestably that the presence of water increases the elasticity of the gaseous mixture, and consequently the yield. It is necessary at first to burn alcohol with an excess of oxygen, in order to avoid the formation of corrosive substances. As alcohol attacks metals, iron and aluminium are rejected, and carbureters of bronze or nickel are alone employed.

The carbureter ought to respond to the following conditions: (1) complete vaporization of the alcohol, to prevent any liquid particles from being introduced in the motor; (2) dilution of the alcohol vapor with a suitable quantity of air; (3) the intimate stirring of the alcohol vapor and air to produce a homogeneous explosive mixture.

The ignition should be produced by *magneto* for powers above 5 horse power, and for burners of motors of feeble force. Scale and other difficulties are due particularly to the employment of gasoline motors utilizing alcohol.

To study the yield of alcohol motors suitably, present information is insufficient. The theoretical experiments of M. Oelkers have indicated the following yields of various motors: Steam, 13 p. c.; lamp petroleum, 11 to 13; gasoline, 15; alcohol, 23 p. c.

The situation of alcohol is to be compared with that of poor gas at its first application. The first experiments were made with motors designed for rich gases and gave bad results. For the employment of poor gas, it was necessary to construct special motors, from which good results were obtained. The same would probably be the case with alcohol.

The question of the cost price is also premature, especially in France, where the price of gasoline depends on the law of supply and demand, while that of alcohol is at the mercy of legislative changes.

Under present conditions, the employment of alcohol cannot be advantageous except when the price is three-quarters that of gasoline, since to produce the same work 1.25 times more alcohol is required than gasoline. Carbureted alcohol has yielded the following results:

	Carbureted alcohol. 50 per cent.	Gasoline. (680)
Expense per H. P.....	0.735 l.	0.677 l.
Outside of Paris.		
Cost of liter	0.45 fr.	0.50 fr.
Cost of H. P.....	0.330	0.338
In Paris.		
Cost of liter.....	0.55	0.70
Cost of H. P.....	0.404	0.473

Comparison is distinctly in favor of carbureted alcohol. In fine, it cannot be denied that the employment of alcohol as a motive force has received much encouragement of late years.

HEMP INDUSTRY.

A DESCRIPTION of the hemp industry in the United States, by Mr. Lyster H. Dewey, Assistant Botanist, American Bureau of Plant Industry, has been published in the Year Book of the Department of Agriculture, from which the following particulars are obtained:

The hemp plant (*Cannabis sativa*) is an annual, belonging to the nettle family. It grows to a height of from five to fifteen feet, and when cultivated for fiber produces only a few small branches near the top of the slender stalk. Its leaves, of a rich dark-green color, are composed of five to nine lanceolate, serrate, pointed leaflets, two to five inches in length and about one-sixth as wide. The staminate or pollen-bearing flowers, and the pistillate or seed-producing flowers, are on separate plants, both plants being nearly alike, but the staminate plants mature earlier. The stems are hollow, and in the best varieties rather prominently fluted. The fiber consists of numerous series of long cells in the inner bark, firmly knitted together, which, when cleared from the surrounding tissues, form tough strands nearly as long as the entire plant. This is a bast fiber, and is classed commercially among the soft fibers, with flax, ramie, and jute.

The hemp plant originated in Central Asia, but it is now widely distributed, especially in the north temperate zone, growing spontaneously where it has been accidentally introduced with bird seed, or cultivated for the fiber.

The name "hemp" was first applied to the plant above described, but in recent years it has unfortunately been used to designate the sisal plant, or henequen, a species of agave producing a leaf fiber, and the manila fiber plant, or abacá, a kind of banana plant producing structural fibers in the leaf petioles. Sansevieria, a tropical genus belonging to the lily family, includes three or four fiber-producing species, often called bowstring hemp, and an East Indian species, *Crotalaria juncea*, is commonly known as Sunn hemp. The name is also applied to several other species of less importance.

Hemp fiber is long, soft, very strong, and capable of almost as fine subdivision as flax. It is especially adapted for use where strength is required. It is used in the manufacture of fine twines, carpet thread, carpet yarns, sailcloth, and for homespun and similar grades of woven goods. Nearly all of the best grade of long fiber, "dressed line," is used for making twines, yacht cordage, etc.; cheaper grades are made into binder twine. The tow is used for threads and for yarns to be woven into carpets, homespuns, and linen goods, and the refuse fiber combed from the tow is used as oakum for calking ships. The average annual consumption of hemp fiber in the United States is about 18,000,000 pounds, of which only about 8,500,000 pounds are raised in this country, the remainder being imported.

Hemp is cultivated most extensively in Russia, China, Japan, Italy, Austria, and France. The tallest and best hemp plants are produced in China and Japan, but the best grades of fiber are imported from Italy, where it is prepared by water-retting. It is not cultivated commercially for the production of fiber in the Tropics.

In the United States, the production of hemp is almost confined to Kentucky. Three-fourths of the American hemp fiber is produced in that State, in the counties of Fayette, Woodford, Jessamine, Garrard, Clark, Bourbon, Boyle, Scott, and Shelby. These nine counties are in the famous blue-grass region, of which Lexington, the principal hemp market, is the center. The most important secondary hemp markets in this region are Nicholasville, Versailles, Lancaster, Danville, Winchester, Paris, Georgetown, Shelbyville, and Frankfort. Small scattered areas of hemp are cultivated intermittently in other parts of the State, and there are probably few counties in Kentucky, in which an attempt has not been made at some time to establish the hemp-growing industry.

There are two centers of hemp cultivation in Nebraska—Fremont and Havelock. During the past two or three seasons, about 100 acres have been grown at each of these places. In California, hemp is cultivated at Gridley, in Butte County. The industry has been gradually established there during the last half dozen years, and having passed the stages of experiment and loss due to new and untried conditions, there is now a tendency to develop and increase the acreage. Trials in hemp cultivation have been made on Ryers Island, near Riovista, in the Sacramento Valley, and in San Benito County. During the past two years, hemp has been grown successfully on a small scale near Houston, Texas, and with improved methods of handling the crop it seems probable that it may become a profitable industry in that region. Hemp has been grown in the vicinity of Champaign and Rantoul, in Eastern Illinois, and along the Missouri River, between St. Joseph and Kansas City, but its cultivation in these localities has been almost discontinued, except at Rantoul, where about 400 acres are still cultivated each year.

Hemp is cut when the staminate plants are in flower. The time of harvest varies from 80 to 140 days from the date of seeding, the period of growth depending on the mean temperature and the supply of moisture, and on the variety. When sown at the proper season hemp is usually cut late in August or September (in July in California and Texas).

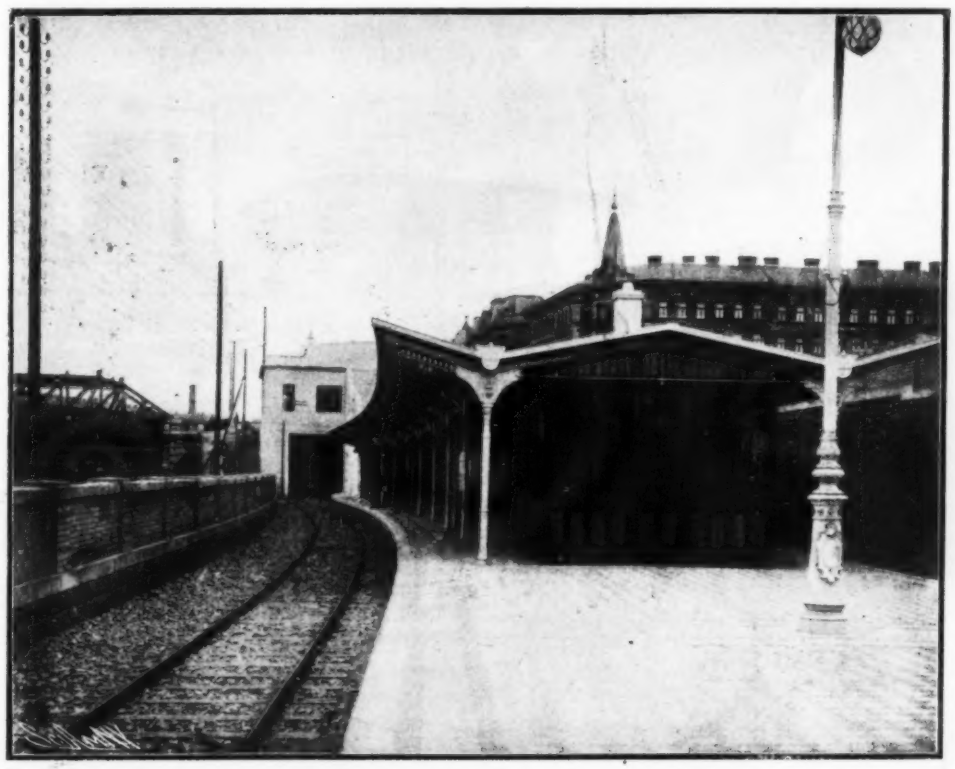
In some instances good fiber has been secured in Nebraska from hemp cut before flowering, but ordinarily the fiber is best when the crop is harvested just before the staminate plants are in full flower. If cut too early the fiber will be fine, but lacking in strength, deficient in yield, and wasting at every operation in its preparation. If allowed to become too mature the fiber will be coarse, harsh, and brittle.

Retting, or "rotting," is a process in which the vegetable gums surrounding the fiber are dissolved and the fiber is at the same time freed somewhat from the woody interior portion of the stalk and also from the thin outer cuticle. These gums are not soluble in water, but they are destroyed by a kind of putrefaction which takes place when the stalks are immersed for some time in soft water or are exposed to the weather.

Retting by immersing the stalks in water is largely practised in France and Italy, and it was practised in the United States until the middle of the last century, before hemp was so completely superseded by cotton in the manufacture of fine woven goods. Water-retted fiber is lighter in color and finer in texture, and it commands a higher price than dew-retted fiber, but it requires a large amount of labor and expensive retting tanks. No process has yet been devised in America by which hemp can be water-retted so as to make it yield as great a profit as when dew-retted.

Investigations in Europe have demonstrated that certain micro-organisms are always present in flax when retting, and these agents play a most important part in the retting process. It is suggested that pure cultures of these amylo-bacteria can be made to facilitate the retting in much the same manner that fermentation is started in making wine and vinegar. In experiments conducted on a small scale flax was retted much more rapidly when the bacteria were supplied. The process of retting hemp is exactly the same as that of retting flax, and it is possible that by making use of the necessary bacteria the length of time and labor required for water-retting may be reduced to within the limits of profitable production. It seems impracticable, however, on account of the great bulk of the crop, to attempt to carry on the operation of retting under cover, as would be necessary in order to have the conditions under control. It may be possible to use the bacteria in a solution to spray on the hemp as it is spread for retting in the field.

Nearly all the hemp now produced in the United States is dew-retted. It is spread in long rows on the ground during the fall and early winter and exposed to the weather until the bark, including the fiber, readily slips from the inner woody portion. In Nebraska and California the hemp is spread in the stubble fields where it has been cut. In Kentucky it is usually spread in closely cropped blue-grass pasture land, and is sometimes hauled two or three miles from the hemp fields to the retting grounds. The plants are



THE BRIGITTE BRIDGE STATION.

THE VIENNA METROPOLITAN RAILWAY.

turned at least once to secure even retting, the tops being thrown over in the same manner as when turned in drying.

Breaking is the process by which the fiber is separated from the stalk and roughly cleaned. It prepares the fiber for market as rough hemp, and is usually the last operation performed on it by the farmer or hemp grower. The work of breaking begins as soon as the retted hemp is ready, and often continues until late in the spring. The greater part is broken during January and February.

Several machines have been devised for breaking hemp, but they have not given complete satisfaction. Very few of them have succeeded at all in breaking hemp in commercial quantities.

TANDEM COMPOUND EXPRESS LOCOMOTIVE—RUSSIAN EMPIRE RAILWAYS.

THE standard express engines of the St. Petersburg-Warsaw section of the Russian State Railways are compounded on the tandem system. There are many of these engines now in service both upon this and other lines, and so far as we know, they are the only locomotives in Europe built upon this plan to any extent, if we except the standard express engines on the Hungarian State Railways.

The conditions for the construction of these machines were that they should haul loads of 270 tons net, upon rising gradients of 1 in 125, at an average speed of 32 miles per hour, or at 62½ miles per hour in descending the same inclines with the same load. In actual service much more can be obtained from these engines, for in the first trials they covered the distance between St. Petersburg and Pskow—171 miles—in 3 hours, 31 minutes, or a commercial speed throughout of 48½ miles per hour, in which run the maximum speeds were kept below 68½ miles per hour, showing that it is not for the want of locomotive power that Russian trains do not travel faster in everyday services. On this occasion there were ten of the immense double-bogie broad-gage coaches of the Russian railways, which, with the locomotive, represented a dead load of 363 tons. The admission to the cylinders, on the level and on slight gradients of 1 in 200, was 55 per cent of the stroke, the theoretical tractive effort was 7,920 pounds, and the work indicated in the cylinders was 900 horse power, the coal consumed being 1,474 pounds per square meter of grate area, and the evaporation being 24.2 pounds of water per horse power hour. The steam production was 156 pounds per square meter of the total heating surface, or 6½ pounds of steam per pound of coal.

The general make-up of the design has peculiarities which are to be explained by local influences. For instance, the rearward position of the bogie relieves the driving wheels of a weight which would otherwise exceed the prescribed limits; the low-down position of the boiler is permitted by the width of the gage—and therefore of the wheels—and, as a consequence, very high domes and chimney are possible, the latter reaching to nearly 16 feet above rail level. The great size of the domes augments the steam capacity of the boiler without increasing its weight, as would do a large boiler with a small dome. An English engineer would undoubtedly arrange the whole design differently to answer the same local needs; but apart from the boiler, its mountings, and the cab, the remainder (engine and running gear) is not abnormal; and if each individual part of the motion be examined, it will be seen that the whole has been very carefully studied to reduce the weight to a minimum. The Walschaert's valve motion, the piston crosshead, the guide bars, the main driving rods, and the side coupling rods are extremely light, and probably nothing could be found anywhere wherein proportions so much differed from the usual American work. The mechanism is, moreover, simplicity itself, there being nowhere two parts where one would suffice. Each of the four cylinders has a piston valve, the two groups on either side being actuated, of course, from a single valve rod, with one valve gear, as for a single-expansion engine.

Of the results thus far obtained with piston valves for the low-pressure as well as for the high-pressure cylinders, we are unable to give details, but it is hardly to be supposed that these cylindrical valves have been exempt from the troubles inherent to the type. All four valves are 8⅝ inches diameter, and give external admission. The lap for all ports is 1⅛ inches (28 millimeters); the high-pressure valves are allowed no inside clearance, being line and line, but the low-pressure valves have a lead to exhaust of 3-16 inch (5 millimeters). The lineal advance is ⅜ inch, and maximum valve travel forward and backward 3 inches (75 millimeters). Between the two valve stems of the same group there is a screw buckle with lock arrangement for adjusting the valves, and the valve stems pass through, and are supported by, all four valve covers.

The walls of all the valve chests are 9-16 inch thick, and their whole circumference is pierced, as usual, with bridged ports, though it may be doubted if the steam ever passes other than by those nearest the steam pipes. The steam ports have widths of 1¾ inches for high-pressure, and 1⅝ inches for low-pressure, and exhaust ports widths of 3⅛ inches for high-pressure, and 3¾ inches for low-pressure. The ratio of the cylinder sections to that of the port areas is 8 for the high-pressure and 18 for the low-pressure. The clearance volumes allowed are much below the usual practice for high-speed engines, being only 8 for the high-pressure, and 6½ for the low-pressure in per cent of volume swept out by each stroke of the piston.

Each group of tandem cylinders is cast in one piece and bolted, at an inclination of 1 in 20 from the horizontal, to especially thick iron frames (1 3-16 inches). The cylinders are 14⅝ inches and 21½ inches diameter, the piston stroke being 24 inches. When new, the high-pressure walls are 23 millimeters thick, those of the low-pressure 25 millimeters thick. The rear cylinder covers are held to their seatings by means of outside rings screwed to the cylinder and walls. Pistons are of steel, the low-pressure being screwed to the rod, while the others are held to their rod seatings by means of nuts and lock-nuts.

The piston-rods are 2½ inches and 3 inches in diameter; the channeled connecting-rods and coupling-rods have closed, or box, ends fitted with brasses lined with antifriction metal.

The valve gear—generally called after Heusinger von Waldegg in Russia and Austria—has expansion links of the box type, worked from a bellied weigh bar of almost square section, supported at mid length by an outrigger bracket screwed to the boiler.

The whole of the mechanism bears the impress of excellent work.

The disposition of the wheels in this engine is characteristic of Continental types wherein the limit allowable for the load under the driving tires has been reached, and any advance beyond which necessitates the adoption of a pair of trailing wheels, or the $\frac{4'}{10}$ coupled type, as has already been done with the Russian engines built for another line, also touching at Warsaw. The long fire-box between the coupled axles, the consequently long coupling-rods, the deep frames, bored with holes to correspond with every hollow copper stay, the bogie truck set far back to relieve the weight on the drivers, and, in general, the reduction of the weight everywhere to a minimum, are all details dependent upon the full limit of weight with only four axles.

The boiler is made of iron plates ⅝ inch thick, with butted longitudinal joints, double cover-strapped, and with lapped circumferential seams, the smallest barrel ring being in the middle. It has an inside diameter of 4 feet 6¾ inches at the front ring, and the smoke-box is increased to 5 feet inside diameter by the insertion of a welded hoop of iron over the front ring of the barrel. The smoke-box is of 7-16 inch plate, and the fire-box curved roof sheet is of ⅞-inch metal. The working pressure is 191 pounds. The staying of the boiler is of the simplest kind—four transverse stays for the curved sides of the fire-box shell—while the flat surfaces of the back plate and of the smoke-box tube plate are stiffened with girder stays and angle irons without longitudinal tie rods.

The fire-box is of copper, 7 feet 10 inches long by 3 feet 5 inches wide at the bottom, and 6 feet 1 inch in height above the foundation ring. The thickness of the copper is 1 inch for the tube plate, 9-16 inch for the sides, and ⅝ inch full for the crown sheet. This latter is stayed entirely with direct iron bolts, and the sides with copper stays, opened out externally, the pitch of horizontal and vertical rows being 4 inches.

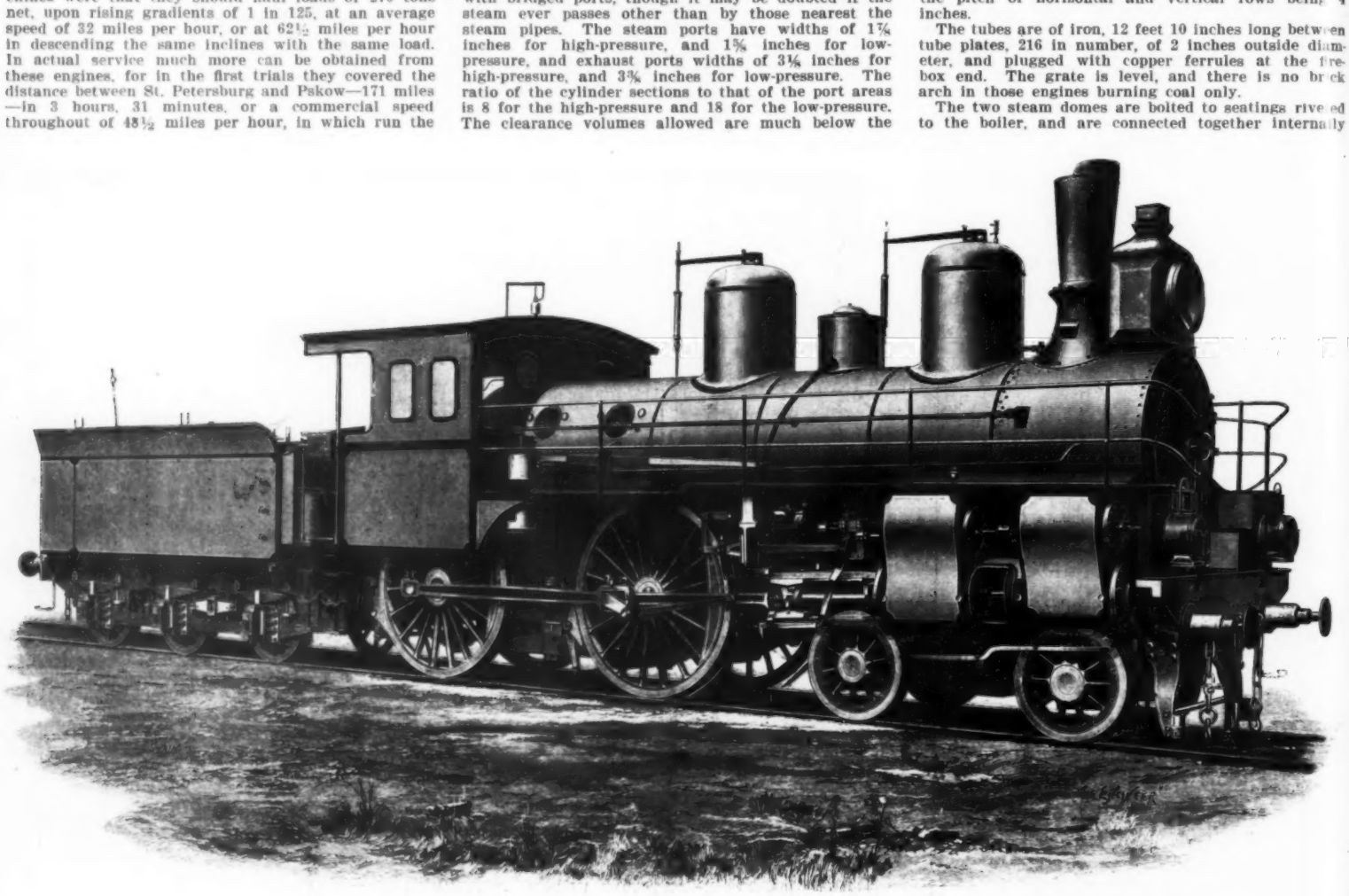
The tubes are of iron, 12 feet 10 inches long between tube plates, 216 in number, of 2 inches outside diameter, and plugged with copper ferrules at the fire-box end. The grate is level, and there is no brick arch in those engines burning coal only.

The two steam domes are bolted to seatings riveted to the boiler, and are connected together internally by a 5-inch collector pipe, having at each of its extremities in the domes a buffer trap to intercept the direct rush of wet steam to the cylinders. There is, of course, a perforated baffle plate or diaphragm about the middle of each dome; and the regulator standpipe is contained in the forward dome and provided with a throttle, the flat slide of which is triangular in form.

The large smoke box is 4 feet 7 inches long, and provided with a cinder trap underneath, 14¼ inches in diameter at the top, and curved forward below the front buffer beam to permit of its being raked out without the man having to go below the engine to do this when the front door is closed. The blast nozzle is fixed. It is bolted to the exhaust pipe within a perforated sheet metal cylindrical spark arrester, which shuts in the space below the capacious chimney base. The hole in the top of the smoke-box is 27½ inches diameter, and the cast iron chimney base above it is 25¾ inches in height. The upper part of the chimney is of sheet iron 3 feet 3 inches in height, and surmounted by a wind-cap 5½ inches deep, the total height above rail being 15 feet 9¾ inches. The chimney apertures are 16 inches minimum and 21¾ inches at the top.

The side frames are 1 3-16 inches thick, and have at the fire-box end a depth of 3 feet 4 inches. They are strongly braced together by transverse and longitudinal platings, and by a built-up caisson, 5 feet 6 inches long, between the tandem cylinders. At the fire-box end the boiler is supported upon brass-lined expansion brackets, and at the opposite or smoke-box end it is secured to its seat on the caisson saddle by brackets, which project downward and clip around the saddle plate so that the boiler barrel can there dilate freely.

The bogie side frames are placed inside the wheels,



RUSSIAN TANDEM COMPOUND EXPRESS LOCOMOTIVE.

with axle-boxes outside of the frames. Their plates are 1 1-16 inches thick. The truck is of the direct-traversing type, held flexibly to center by a double elliptical spring. The pivot is a steel casting of large size, the neck of the pivot being hollow, 7½ inches diameter, and the weight being carried on a flange 2 feet diameter, stepped into a deep collar-bearing, also of steel castings, lined with bronze. The pivot is held to its seating by a central pin 8 inches long and 2⅜ inches diameter.

To prevent any chance of binding or strain the pivot neck is rounded slightly, as the outer edges of the engine frame have no rigid supports, coiled springs being used instead for the lateral steadying of the main frame. A feature to note also is the spherical ends of the camber pins of the bogie springs, stepped into corresponding holes in the axle-box crowns.

An exceptional arrangement exists in the double or trussed equalizing levers of the driving springs and by which the weight is carried between the two plates on a pair of knife-edged supports in place of the usual fulcrum pin. The bracket by which the frame is supported projects downward from the latter and passes between the trussed plates of the equalizing beam.

The cab fittings are of the simplest possible form, and very few in number. The regulator handle has an unusual disposition, it being jointed in two parts so that the engineman can work it from either side of the footplate. The two parts mesh together by means of toothed quadrants, and a latch in the handle locks the two halves of the lever at any angle of adjustment. There are two injectors, Friedmann's No. 9, and the brake is the Westinghouse.

A good deal of space is available in the cab, which is exceptionally wide, and provided with the deep front windows so convenient in American cabs. A door gives access to the running board on the fireman's side, and the whole of the footplating is provided with the regulation Russian guard railings. Gutters and spoutings are fitted to the cab roof.

The tender carries 5 tons of coal, and 14 cubic meters, or 14 tons, of water. It runs on six wheels, of 3 feet 7¼ inches diameter, having a total base of 27 feet 11 inches. Equalizing beams connect the ends of the two pairs of forward axle springs. All springs have spherical ends to the camber thrust pins where they rest upon the axle-box crowns. An elliptical spring is used for the buffing and draught arrangement at the front of the tender, and a volute spring is employed for the draft hook of the front buffer beam of the engine. Rubber ball cushions are provided on the safety chain hooks. The tender is exceptionally wide—9 feet 10 inches—and a lining of wood is interposed between the tank and framings upon which it rests. The height of the water is indicated by a float connected to an index hand. The following list completes the general dimensions:

Cylinders (four)—	
High-pressure, diameter	0.365 m.
Low-pressure "	0.547 m.
Piston stroke	0.610 m.
Wheels—	
Coupled, diameter	2.000 m.
Bogie "	1.000 m.
Journals of driving axles	.195 mm. dia. × .260 mm. long.
" bogie "	.175 mm. dia. × .300 mm. long.
Tractive effort, maximum	6525 kilogs. = 14,355 lbs.
Boiler—	
Heating surfaces, exterior, of firebox	13.68 square meters.
Heating surface, of tubes	132.40 "
Total	146.08 "
Grate area	2.615 "
Boiler pressure	13 atm.
Capacity of boiler for water—	
10 cm. above fire-box crown	4.65 cubic meters.
Capacity of boiler for steam—total	2.48 "
Volume of the two domes	0.808 "
Height of boiler center from rails	2.500 m. = 8 ft. 2⅝ in.
Areas and ratios—	
A, area of air passages in grate	0.960 square meters.
B, " " tubes	0.344 "
Ratio of A to B	2.7
Ratio of total heating surfaces to grate area	55.8
Ratio of tubes heating surface to that of fire-box	9.68
Frames, inside—	
Width apart	1.290 m.
Length	10.364 m = 33 ft. 8 in.
Thickness of plates	.053 m.
Weight—	
Engine, empty	51.5 tonnes.
" loaded	56.5 "
On each bogie axle	13.25 "
" driving axle	15.00 "
Tender, empty	16.00 "
" loaded	35.00 "
Engine and tender, loaded	91.50 "

—Engineer.

SOME ENGINEERING FEATURES OF DRAINAGE.*

By C. G. ELLIOTT, Drainage Expert, Office of Experimental Stations.

INTRODUCTION.

WHATEVER may be said regarding the value of drainage in its various relations to industrial progress, its most far-reaching and lasting benefits arise from purely agricultural sources. It has been the means of greatly increasing the productive capacity of large areas and contributing to the comforts of country life.

Those who are unacquainted with the principles and practice of drainage for agricultural purposes have but to compare the unproductive swales, overflowed river bottoms, and limitless swamps which may be found in partially developed sections of our country with some of the most productive farm lands and prosperous communities of this and other countries, to understand in some measure the magnitude of the results which have been brought about by the practice of drainage. The engineering and legal difficulties which have been surmounted in the accomplishment of these results have enlisted the services of prominent statesmen as well as able engineers. In recent years the subject has attracted the attention of discerning business and professional talent to such an extent that the intelligent development of lands by methods known to the engineers is becoming better understood and more widely practised.

* From Year Book of Department of Agriculture,

The occasion for increased interest in this subject becomes more pronounced each succeeding year. In the opening up of a country it is natural that cultivators should first seek out and appropriate those lands which, by reason of their location and natural condition, are best suited for productive purposes, and can be cultivated with the least possible outlay of labor and capital. The neglect of waste lands, whatever

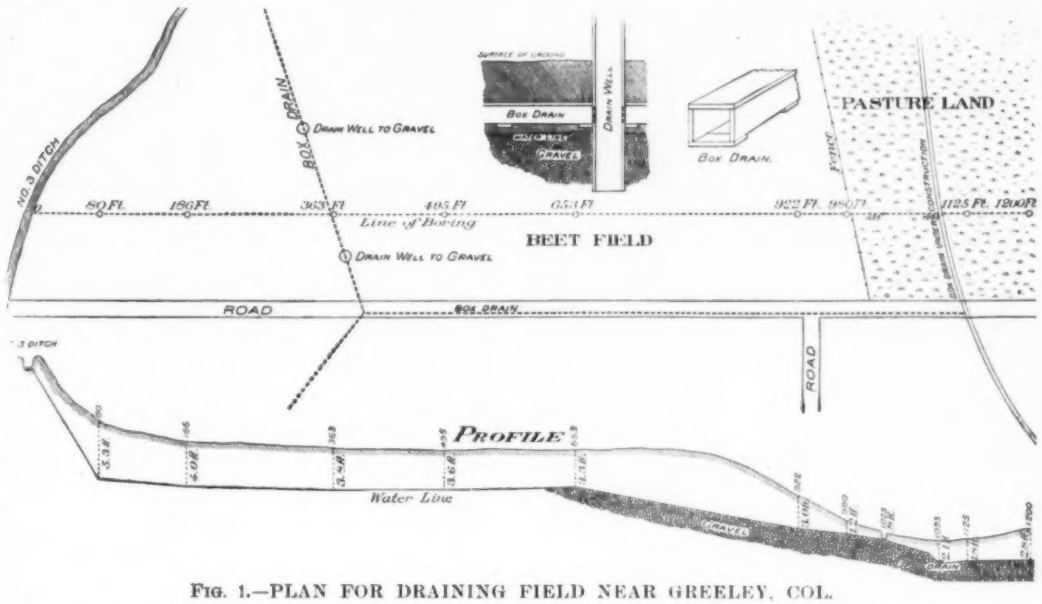


FIG. 1.—PLAN FOR DRAINING FIELD NEAR GREELEY, COL.

their condition or area, occasions but little concern as long as there is a sufficient acreage of easily accessible arable land to occupy the attention of the agricultural people. With the increase of population and a corresponding added demand for food products, the reclamation of waste lands by drainage in such a manner as to fit them for the production of valuable crops, and the improvement of those already cultivated for the purpose of adding to their productive capacity, have assumed an important place in both agricultural and commercial activities.

Not only is the reclamation of land required in humid regions, where it has been supposed that the art of land drainage is alone applicable, but irrigated areas in the West furnish many instances which emphasize the need of drainage for lands which have been reclaimed by the artificial application of water. In fact, it may be said with truth that all lands require drainage, either by natural or artificial means, if they are to be relied upon to yield their best fruits to cultivators. A proper regulation of the quantity of soil water is necessary, be it furnished by rainfall direct upon the surface or by methods used in irrigation. The problem which confronts the engineer contains three important considerations which he should take into account: (1) The quantity of water which should be removed from the soil; (2) the plans and methods to be employed in accomplishing it; and, (3) provision for the proper disposal of the water removed.

DRAINAGE OF RAINFALL.

With reference to the division of this subject most commonly recognized—that is, the drainage of lands receiving their water from rainfall—it may be said that the quantity to be removed is subject to several modifying contingencies for which due allowance, as far as practicable, should be made. This phase of the subject, when discussed in works on drainage, is often dismissed with a mere reference to the average rainfall of the locality and a few remarks upon the value of such data in planning an efficient drainage system.

It is not the average rainfall with which we are concerned in land drainage, but the maximum precipitation at various times during the growing season. This should be considered in connection with conditions of soil and weather at such times. It is not infrequently the case that after a season of drought a rainfall of 2 inches of depth in twenty-four hours may be fully absorbed by the soil, while at other times and under different conditions a large part of a like precipitation must be provided for by either surface or underdrainage or a combination of the two.

SURFACE STORAGE.

The storage capacity of the surface of the land which may be used without detriment to its productive value occupies an important part in the plans for drainage, especially where large tracts are under consideration. The percentage of slope of an area toward its natural drainage courses and the obstructions which retard the surface flow of rainfall present engineering problems of a local nature. For example, where the tract is large and nearly level, the movement of water by both natural and artificial drainage is slow, and a larger percentage of rainfall is evaporated, stored in the soil, and used by the plants in a given time than where the slopes are sufficiently great to make the run-off rapid, thereby overcharging main drainage channels for a short time and carrying off water which it would be better to have pass over or though the soil more slowly. For this reason the drainage of level areas of large extent can be accomplished with smaller main channels, considering their carrying capacity, than that of more undulating land with irregular and varying contour. It may be further said that the results arising from such drainage are more salutary,

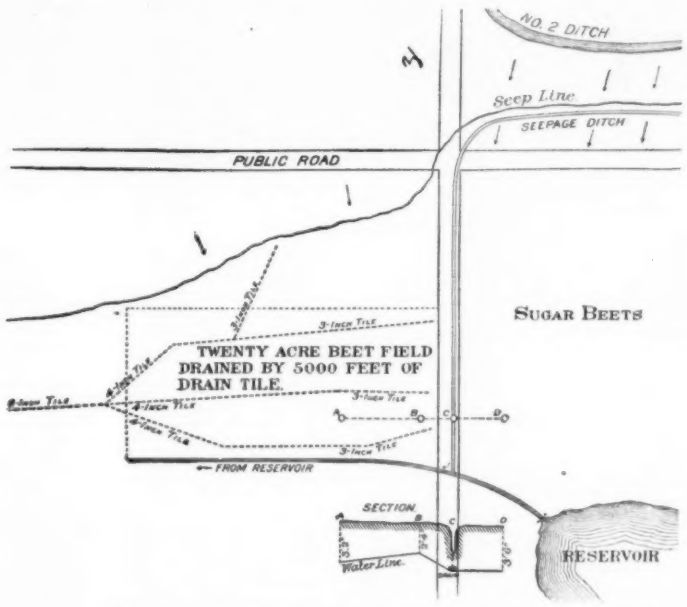


FIG. 2.—DRAINS AND SYSTEMS OF LOCATION ON FARMS NORTHWEST OF GREELEY, COL.

and have attracted wider attention than in the latter case.

As an example, it may be assumed that the main drainage of a tract of large extent and level contour may be provided for by a channel computed to carry one-half inch of water in depth from the entire area from which it receives drainage in twenty-four hours when the channel runs eight-tenths full, two-tenths of the full carrying depth being reserved for contingencies not entering into computations for channel capacity. The methods of draining the interior of the tract, and the subsequent uses to be made of the land, have a modifying effect upon the work which the main drainage will be called upon to perform. If done by systems of underdrains, with supplementary open-

ditch laterals, the time taken for the removal of water will be extended several days, thereby making the maximum discharge required of the main channel sometimes 10 per cent less than where the entire work is accomplished by surface drains alone.

The considerations which will apply to land just described, with reasonable accuracy, will be far different for a tract of rolling or broken land interspersed with level areas. Here, again, the degree of slope and the changing character of the soil and surface conditions present a variety of important features for the attention of the engineer. The maximum quantity of drainage to be provided for in twenty-four hours may be one inch of depth, or even more, for the entire watershed, with many complex questions of interior drainage to look after. The aim should be in such cases to hold back and distribute the water from the more elevated lands rather than to concentrate it; to provide for its entrance into and passage through the soil rather than over it; to store a portion of it in the lower strata of the soil instead of hurrying it into the main drainage by the most direct course possible. At the same time, the level portions must be protected and drained in accordance with the requirements of their peculiar situation. A due regard to these considerations in the planning of drainage works for lands, such as just described, will retard the surface wash, prevent waste of soil from rolling lands which adjoin level flats, and conserve moisture needed for the higher lands, while, at the same time, it will assist in taking care of the drainage of contiguous low-lying or valley lands and arrest the distribution of rainfall through the soil by artificial drainage as well as by surface control. This is an important engineering feature of drainage which merits more attention than it has heretofore received. While the quantity of water to be removed from soil and the plans for accomplishing it are analytically different subjects, it is not difficult to understand, from what has already been said, that in practice they are intimately connected. The quantity of water to be provided for in a given time will have much to do with the design of plans and methods of accomplishing the drainage of lands.

The details of this work involve the consideration of numerous local conditions. While the general principles are the same, the surveys, computations, and plans for the accomplishment of efficient and economical work in any particular locality should be evolved in accordance with the conditions and surroundings peculiar to it. The engineer's treatment of the case must be largely influenced by precedents and former practice under analogous conditions. In this regard, however, drainage engineering is not unlike other divisions of practical work directed by scientific methods, but investigations along this line have not been as persistently and carefully pursued as those for other divisions of hydraulic work.

DRAINAGE OF IRRIGATED LANDS.

While the drainage of humid lands has been practised for years and its utility is well established, its importance in the cultivation of irrigated lands has only recently forced itself upon the attention of owners. The necessity for drainage here, however, arises from causes so different from those which prevail in humid areas, and the conditions of soil, methods of cultivation, and weather are so different that a description of them will be necessary to a proper understanding of the situation. Strange as it may seem, there are some areas now requiring drainage which were once almost destitute of soil moisture.

The water which has converted the desert into the productive farm is derived from streams supplied by the melting snows of the mountains. Portions of these streams are diverted at various convenient points after they leave the mountains and the desired quantity of water conducted for miles, by means of ditches, to those lands which it is destined to irrigate.

Laterals are taken out at favorable points and the water used upon lands until the last diminutive stream vanishes in the greedy sands of an unwatered plain. These ditches pass across the slopes and around the hills in such a way as to maintain the light grade necessary, and upon elevations sufficient to give water service to a large acreage of lower lands. The soil through which they are constructed often contains large quantities of gravel and sand, or, in some cases, laminated shale, making it the most unsuitable material possible through which to form a water conduit. In some cases they pass through gypsum formations, which material, besides having a remarkable affinity for water, permits excessive leakage by reason of the loose structure which is usually a characteristic of such beds. When first constructed it requires some time to get water through the entire length of the ditches, and not a little expense is necessary to repair injuries done to them by washouts and the settling of bottoms, which take place during the early history of every canal. While these losses diminish greatly after the banks of the canals have become settled and the crevices closed by silt, the loss of water is never effectively checked where the canals pass through loose earth, but continue to add to the underground waters of the plain. This loss has been detected by comparisons of measurements of the quantity of water taken out of the stream with those representing the sum total of water distributed. This is called "loss by seepage," and varies from 15 to 95 per cent of the entire volume diverted from the stream. The waste finally reaches, at some lower point, the stream from which it was originally diverted, and is classified as "return waters."

Could the ditches pass through earth practically impervious to water, or could they be lined with some preparation to make them water-tight, the conditions which prevail on the lower lands would be far different, but owing to the great size and length of many of these canals, the difficulties and expense attending this process are such as to be practically prohibitory. The losses by leakage in most instances are accepted as contingents of irrigation systems. The elevated position of the water carried by the supply ditches furnishes a constant pressure head to every stream of water, however small, which finds its way through the bottom of the channel. To this head and to the permeability of the earth may be attributed the presence and dissemination of seepage water, which, in time, manifests itself upon lands which have been irrigated and successfully cultivated for a term of years.

The soils in most irrigated regions are deep and loose, containing a small percentage of clay, but rich in concentrated plant food. They are finely divided and possess great capillary attraction for moisture; and, moreover, their physical structure is such that they are most easily kept in perfect condition by judicious cultivation. Further than this, they permit a ready passage of water through them after capillary spaces have been filled. The rainfall is so far deficient that water must be obtained from supplies diverted from mountain-fed streams and brought and distributed by ditches. The effect of this application of water to soils under judicious management is remarkable, as the abundant and valuable products obtained from such lands attest. The irrigator applies water by surface flooding, using such quantities as his judgment and experience may dictate, feeling sure that any excess which he applies will speedily pass to the lower soil, which, under primitive conditions, being dry to a depth of from 40 to 60 feet, porous and open, affords unlimited drainage facilities. The large amount of leakage from the main canals for a time finds a ready and harmless exit into the lower soil. Under such conditions the under strata become a regulating reservoir, which receives by percolation the leakage from irrigation canals and drainage from over-irrigation, thus securing to the cultivator as perfect soil conditions as can be desired.

FILLING UP OF THE SOIL WITH WATER.

Under such conditions it will be only a matter of time when the lower soil will become filled with water and this will rise until the saturation extends to the surface, similar to that with which we are familiar in humid climates. These conditions already exist in all of the older irrigated lands in such a degree as to call emphatic attention to the injury done and to cause no little concern regarding the proper treatment of the lands which have become saturated. That the injury to lands from this cause is increasing rather than diminishing and that some plan for their drainage should be made and put in operation are conclusions reached by careful observers of the changes going on in irrigated districts.

THE PROCESS OF SEEPAGE.

A few general facts observed in California and Colorado may be valuable to those who are unfamiliar with this new drainage question. As would be expected, soil water usually first appears on the surface of the lower levels of land, being brought there by percolation through the soil from some more elevated supply, which forces water through the soil more rapidly than its natural drainage facilities will remove it. In other instances it appears not far from a supply ditch, the underflow having apparently been arrested in its passage through the soil by some less pervious material which has caused the water to rise to the surface instead of continuing its course through the soil at sufficient depth to be harmless to vegetation, until it finally reaches some drainage stream. In the areas which are nearly level the appearance of the surface water is more general, the quantity depending much upon the texture and condition of the lower soil. The saturation of irrigated land by seepage from supply ditches and from over-irrigation will alone destroy their productive value as effectually as surplus water is known to destroy the productivity of lands which are overcharged with rainfall.

ALKALI CONDITIONS OCCASIONED BY LACK OF DRAINAGE.

There is an additional menace, however, accompanying the saturation of these soils which is peculiar to them and which in many instances manifests itself before the water appears at the surface or is at all troublesome to cultivators. Many of these soils contain considerable quantities of sodium chlorid, sodium sulphate, and sodium carbonate, which originate in the rocks from which the soils are formed and are distributed through them, forming an essential part of their fertility under normal conditions. Lands which up to a certain time have produced crops in quantity and quality to which no exception can be taken may, without apparent cause, begin to deteriorate and continue to do so. Upon examination, it will be found that the alkali salts have accumulated near the surface in such strength as to destroy crops which had previously been successfully grown. Upon further investigation as to the cause, it is found that the abundance of water in the lower soil has dissolved large quantities of alkali and holds it in solution. The rise of water to a plane at or near the surface from which rapid evaporation takes place results in a deposit in solid form of all alkali contained in the water evaporated. The active capillary power of the more finely divided soils accelerates the upward movement of the water, the evaporation of which is rapid in the arid climates, resulting in a deposit which constantly increases from year to year. The first stage of this evil is but the forerunner of the more serious results which follow in the train of oversaturation of irrigated soils, which must be witnessed in order to be fully appreciated. These general conditions are not uncommon to all of the older irrigated districts. The value of drainage to such lands for the purpose of restoring them to their former productiveness, as well as to arrest the progress of the evil when once detected, is sufficiently demonstrated to merit investigation by all cultivators of irrigated soil. In fact, drainage is the only efficient method known for removing alkali.

SOURCE AND MOVEMENT OF WATER TO BE REMOVED.

In the drainage of seeped land under irrigation there are a few fundamental questions which should be considered, the first of which is the source of the water to be removed. The prodigal use of water during the first years of the cultivation of the land under new ditches, together with the enormous losses of water incident to new construction, have contributed largely to produce the water-logged conditions now found in the lower soil. From the history of early irrigation in the Fresno district in California, it appears that a vertical depth of 5 feet of water was occasionally applied in a single irrigation, and the depth applied during a season would sometimes be equivalent to a total of 20 feet. Such extravagant use of water does not often prevail in the older irrigated regions, so that the water requiring attention in drainage is now for the most part derived from the seepage of supply ditches. It comes from the subsoil, and is subject to a constant gravity head furnished by water in the supply ditches, which always occupy a higher level than the surface of the land irrigated. The supply is constant during the growing season instead of intermittent and occasional, as is the case of water from rainfall. The soil is of an open character, and permits the ready passage of water through it. It also has high capillary power and carries water to the surface with remarkable freedom and persistency, much more so than soils containing a large percentage of clay or coarse sand and gravel; hence the depth of drainage is an essential feature of its success, for the reason that soil water should be kept so low that capillary water will be appropriated by the soil and plants before it reaches the surface. This should rarely be less than 4 feet, and greater depth is frequently more efficient. A proper location of drains, both as to depth and position, is of first importance. After the source and movement of water have been ascertained, a single drain may frequently be so located as to intercept and conduct away water which might otherwise destroy the value of hundreds of acres of land. The reclamation of the tracts already seriously injured may be accomplished by the same well-directed measures. There are a sufficient number of instances of successful works of this kind in California and Colorado to establish its efficiency under wise administration. It may be added, also, that the failure of shallow drains and ill-directed location emphasizes the wisdom of careful investigations upon these points.

PRACTICAL DIFFICULTIES IN CONSTRUCTION OF DRAINS.

The practical difficulties of drainage construction in these soils are in some respects quite formidable. The earth is easily and cheaply worked when dry, but difficult and expensive to handle when wet, unless a bed of gravel is encountered; gravel prevents the slumping of the fine soil which, under saturation, becomes semifluid in consistency.

It is a fortunate characteristic of irrigated lands that the plane of saturation begins to lower as soon as the supply of water is turned out of the ditches so that between that time and the beginning of the following irrigating season, ditches for either open or covered drains may be constructed not only with reasonable dispatch, but with an assurance of being in perfect condition when completed. The wisdom of carrying on construction work when soil water is at its lowest stage is apparent to all who have attempted such work in the deep and open soils of irrigated districts.

DISPOSAL OF WATER.

The disposal and use of drainage water derived from seeped lands is a matter of peculiar interest to irrigated regions, because of the value attached to the water as an irrigation supply. Its use, so far as ascertained, is wholesome and may be made without fear of any injurious result from alkali. It may be diverted from the drainage ditch or collected in reservoirs and thence distributed by the usual methods, thus adding to the available supply of water for that locality. Such water has a value, in many localities a high value, and as drainage becomes better understood and more widely practised the water will constitute an important commodity among land owners. In some localities in Colorado it is being developed by drainage works at private expense and appropriated as an additional irrigation supply. Over 400 filings on seepage and drainage streams have been made in Colorado in the South Platte Valley alone, and proceedings at law in that State have affirmed the right of appropriators of such water to its use as against any subsequent appropriation which will divert or interfere with the flow of drainage or seepage streams already filed upon. The development of water by drainage works brings into prominence new legal phases of the water question, which have not thus far been made subjects of legislation, but which should receive early investigation and attention.

KINDS OF DRAINS.

The theory of drainage may appeal with much force to the landowner, and he may have great confidence in the results of the work when carried out, but the matter will receive only a passing notice unless its practice is shown to be feasible and remunerative. This is a feature of the work which commands immediate attention. The different conditions existing between regions where rainfall is a direct source of soil water and where seepage from reservoirs and canals furnish it through underflow suggest a difference in the plans, but not necessarily in the kind of drains which may be used. Open ditches, by reason of the depth at which they should be maintained and the unstable character of the soil, entail a constant expense for cleaning, which is unavoidable. Where the ditches are seldom flushed, their filling by sand, vegetable growth, and surface rubbish carried by winds occasions a necessity for at least one annual cleaning. Box drains are in favor in Colorado, where the quantity of water to be carried does not require a drain of large capacity. The advantages claimed for them are that they are cheaply made and may be secured in place in wet soils with greater ease and certainty than earthen draintile and sewer pipe, which must be laid in short sections. They are used with success where field crops are grown. When constructed with no bottoms, as is common with those of small capacity, their usefulness is limited to low grades; otherwise underwashing will destroy the usefulness of the drain by throwing it out of position. The lasting properties of the lumber used for this purpose will be measured by the degree of continual saturation to which it is subjected. The drains used should be lasting as well as efficient. In Fig. 1 is shown the manner of draining a field of seeped land near Greeley, Col., which was made unfit for cultivation by leakage from the supply canal adjoining. The drains are of the box pattern and laid about 4 feet deep. The diagram shows a profile of the water line, as determined by borings made in August, 1902. There appear to be beds of gravel underlying this

land in some localities. Where these beds could be located, small curbed wells 10 inches in diameter were sunk into the gravel and the drains connected with the wells. It is claimed with good reason that these wells relieve the hydrostatic pressure of the free water in the gravel, the water rising in them and passing off through the drains instead of being forced upward through the soil. The thrifty crop of sugar beets growing on this land the first season after drainage was evidence of the success of the work. At the time these examinations were made a larger and more extended drain was being constructed in an adjoining field occupying a lower level. The profile of the water line shows the need of an additional drain, which will be laid approximately parallel with the supply canal.

Stoneware draintile constitutes an ideal material for underdrains. Owing to the practice of constructing such drains when the soil is saturated with water, there has been some difficulty experienced, in Colorado at least, in placing and maintaining the tile in position and also in keeping them free from sand. Their excellence as a water conduit and their durability are unquestioned. Their cost, however, being much greater than lumber, stands in the way of their adoption in localities which are distant from manufactories.

OPERATION AND LOCATION OF DRAINS.

Notwithstanding their expense, draintile are used with success, to a limited extent, in the fruit lands about Fresno, Cal. A provision for keeping the lines free from small roots, which constantly seek the flowing water, and would soon fill the drains, is found necessary. This is accomplished by passing cylindrical wire brushes through the drains every few months. Manholes, for the purpose of obtaining access to the drains for this purpose, are maintained at distances of 400 or 500 feet along the lines. Where these soils are chiefly occupied by trees and vines the drains must be scoured periodically by some process similar to the above, which will constitute an expense for maintenance peculiar to such localities. For this reason, and also because the grades are light, perfect work in the construction of drains must be secured.

The objection is urged that some kinds of drains are not effective; that water fails to enter them in sufficient quantity to accomplish the desired work; that, notwithstanding their presence, the land they are intended to benefit remains undrained. It is true that there are many instances which apparently support this conclusion. The writer has witnessed cases where underdrains were discharging water in continuous streams, yet the soil directly over them was saturated. In other instances the soil in close proximity to the drain was dry and productive, while 15 feet distant it was producing only water grasses. Open drains are liable to the same objections. The failure of the drains in the cases referred to was owing not to the material of which they were made, but to their faulty location, either in surface position or depth or both. Proper surface position and proper depth are essential factors in the successful drainage of seeped lands. Since the source of water is underground, its course must be found and the drains so located as to intercept its flow in the most effective way. This constitutes one of the arts bearing directly upon the successful drainage of irrigated lands.

It is, however, sometimes no easy task to locate drains properly. In this connection it is interesting to note that no greater impetus was given to the practice of drainage in England than at the time that Joseph Elkington, a Warwick County farmer, unlettered and ignorant, became so proficient in locating surface water and in arresting its course and leading it away that he became famous in neighboring counties as well as his own in draining soil which had hitherto baffled expert engineers. In recognition of his great service to agriculture, Parliament, in 1795, voted him the sum of £1,000 sterling. The Royal Agricultural Society previous to that time commissioned one of its members to collect and publish such information as could be obtained from Mr. Elkington in order that his art might be made available to the people. The same importance should be attached to the location of underground water in irrigated lands. A failure in this particular is largely accountable for the charge sometimes made that water does not enter the drains. The writer calls to mind a field on a farm north of Longmont, Col., that has been drained thoroughly with the exception of one portion of about 2 acres, which, notwithstanding the presence of drains around and through it, remains a swamp. The source of supply has not been found.

While upon this most practical subject pertaining to drainage, reference may be made to Fig. 2, in which are well represented two kinds of drains, as well as two systems of location, which are found in adjoining fields on farms northwest of Greeley, Col. In the one, a system of tile drains has been laid about 4 feet deep through the land immediately affected by seep water; in the other, an intercepting ditch has been made for the purpose of cutting off the water from the ditch before it does injury to the field. Each plan apparently accomplishes the work intended. The tile drains furnish a continual stream and the growing beets on both fields show equal thriftiness. There is a difference, however, in the cost of the two, and borings show that the water line is lower in the land drained by the single cut-off ditch than in the field where tile drains have been used.

FIELD ENGINEERING.

The location of drains should be made when the ground is wet, so that the outcropping water, its effects, and the course of its underflow can be ascertained by suitable test borings. After this has been done, advantage should be taken of the fact that the level of soil water recedes between the irrigating seasons and sinks so low that drains may be constructed in dry ground. The lines should be surveyed, the grade located, and the drain, of whatever kind used, constructed in accordance with the survey. The risk and expense arising from caving ditches, running sand, and all of the contingencies incident to such work would in this way be largely avoided and the drains completed under the best possible conditions. Here is a field for the investigation of the minimum grades which may be permitted under the several conditions to be considered and the best methods of disposal of the water, together with size of drains and specifications of their construction.

THE NEW DRAINAGE FIELD.

There is no question but that there is ample room for profitable investigation in this new drainage field. The irrigation of the arid lands of the West has developed a necessity for drainage which is destined to follow in the wake of the reclamation of all desert land. Owners of such lands should be early apprised of this menace to their property. Care in the application of water and watchfulness for the first indications of saturation or appearance of alkali, with proper preventive measures, will go far toward arresting this growing evil in newly developed districts. It is well proved that alkali in cultivated lands is the result of oversaturation, arising principally from the seepage from ditches. It seems equally well assured that if the water line of the soil can be reduced by drainage to within 5 feet or more of the surface, the accumulation of alkali to an injurious degree will be prevented.

Sufficient work has been done in Colorado to demonstrate that judicious drainage will reclaim lands already saturated, that it will prevent the rise of alkali, and that land which has become water-logged and injured by alkali may by this means be restored to its former productiveness. The success of this promises to be as marked as that of drainage in well-watered States of the East and Middle West. Since the time underdrainage was introduced in New York, in 1836, its value in reclaiming, restoring, and developing the soils of the country has been incalculable. The work still goes on as a well-tried and standard method of increasing the productiveness of the soil. Drainage in the irrigated districts promises equally important results, and will be more universally practised as the lands grow older. When lands have once been proved to be profitable under irrigation it is poor policy to permit them to be ruined by the same agency which has developed their productiveness. Among the numerous instances of injury to lands from this cause, which may be found in different States, there are doubtless a great variety of conditions to be met and many unsolved problems relating to their reclamation, yet some application of the well-established principles of land drainage will be of utmost service. This problem has been considered as applying only to those lands which have been proved by actual cultivation to be of the highest productive value under ordinary irrigation practice. They have not been depleted in fertility, and for that reason abandoned, as is the case with long-cultivated lands in the East. Their value is not impaired for lack of market for their products. On the contrary, they are fertile in every desirable particular, and are capable of producing crops of superior quality, which are sought for in the markets. The lands requiring drainage are often the choicest, so far as location is concerned, and more desirable than new and unimproved areas. The suggestions regarding their restoration to the realm of profitable irrigated lands have been deduced from somewhat limited investigations, and their application to lands in similar conditions in other States may be subject to revision. The subject is certainly one of such importance as to merit a full examination in every district where the conditions herein described prevail.

THE PASSING OF THE ENGLISH SPARROW.*

By HAROLD BOLCE.

THROUGH comprehensive investigation conducted by economic ornithologists, the important discovery has been made that the English sparrow has passed its maximum limit of abundance in the United States, and is now diminishing in numbers. As is well known, a large part of the civilized world long since joined in a vendetta against this objectionable bird. But the English sparrow avoided traps, shunned or survived poison, evaded hunters, and overran the earth.

Now several species of hawks and owls are accomplishing what was impossible to man. Among the most active in the sparrow warfare in the United States is the little screech owl (*Magascops asio*), and in Canada the little saw-whet or Acadian owl (*Nyctala acadica*)—birds not much bigger than the prey they are slaughtering. The number of English sparrows consumed at the banquets of their raptorial enemies is enormous.

Simultaneously with the discovery of the beneficial activities of owls and hawks in checking the dominion of this hitherto conquering bird comes the unique announcement from a medical scientist in the United States army that a species of mosquito is spreading malaria among the great flocks of English sparrows. Officers of the British army medical corps have also made the discovery that a malarial germ, transmitted by mosquitoes, has attacked the English sparrow. It is not probable that the malarial parasite in itself would be sufficiently powerful to decimate the species, but incidentally as a co-worker with the rapacious birds that have combined to conquer the sparrow pest in America, the mosquito assumes new and unique interest. *Proteosoma grassi, hamaneoba relicta* is the name given to the malarial organism which has begun to devitalize the blood of the English sparrows. The mosquito waging warfare on the birds is a species of *Culex*, which, so far as is known, is not a conveyer of disease to man in temperate zones. Its method of transmitting malaria to sparrows is similar to that employed by the genus *Anopheles* in inoculating human beings with the germ. The discovery that malaria has attacked the English sparrow has come about through experiments in permitting mosquitoes that were known to have fed on men and animals suffering from malaria and other maladies to attack live birds. It was believed that without the jeopardy to human life which is involved when experiments are made upon men, important tests could be conducted demonstrating the power of mosquitoes to transmit many diseases, besides malaria and yellow fever. These experiments are still being carried on, and incidentally it has been learned that, without laboratory encouragement, mosquitoes have been diligently at work spreading malarial contagion among the millions of English sparrows in many sections of America. The bird and insect conspiracy against the English sparrow is extensive and formidable. The unremitting slaughter by hawks and owls is visibly thinning the vast army of these birds.

At the time of the introduction of *Passer domesticus*, as the English sparrow is known scientifically, it was believed by many people that it would rid America of many kinds of insects. Experience, however, proved that this bird protected dangerous insects by driving out other birds that had kept them in check. For example, the orgyia caterpillar (*Orgyia leucostigma*), very injurious to shade trees, is a formidable diet, which most birds, including the English sparrow, carefully shun. This noctuid has an armament of bristling hairs which renders it unpalatable to the great majority of insectivorous birds. Furthermore, the robin, the Baltimore oriole, the black-billed cuckoo, and the yellow-billed cuckoo are exceptions to the rule and seem to be charged with the special mission of ridding the earth of these and other hairy caterpillars. It was not only in driving off these four species of birds that the English sparrow gave protection to this particular pest. It was discovered that to some extent the English sparrow, while not insectivorous, did destroy some insects, but in so doing it chose less harmful and more appetizing species, and so, reducing the struggle for existence in the insect world, gave a freer field for such noxious kind as the orgyia, or white-marked tussock-moth, as it is popularly called. That is simply an illustration of one phase of the English sparrow's evil reign. The indictments against the bird, as is well known, are legion. Now with the decrease of the sparrow is noted a corresponding diminution of the destructive insects, for the insectivorous birds once banished are returning. The black and purple martins are coming back in flocks. The "Robin Redbreast" this year reappeared in city parks that for years have been surrendered to the sparrow. Wrens, mocking-birds, swallows, song and chipping sparrows, Baltimore and orchard orioles, phœbe birds, warblers, and yellow-birds are among the joyous company flocking in to resume their minstrelsy in their native parks and fields.

It is confidently believed by economic ornithologists that the whole country will before long feel the beneficial effect of the downfall of the English sparrow. To that end, protection is urged on behalf of the hawks, the butcher bird, the owls, and other species that are performing valiant labors in the interest of American agriculture.

At first English sparrows confined themselves almost exclusively to cities and towns. Gradually, as towns and cities became overrun, the sparrows extended their range into the country. Sometimes when they utilized side-tracked box cars as convenient roosts, they were carried into new environments, but speedily made themselves at home, inaugurating at once a systematic and pitiless warfare upon the insectivorous and song birds of the neighborhood. Farmers who had not seriously regarded the hostility of city people toward sparrows soon realized the secret of that feeling. In some localities orchard and field crops have been almost totally devoured. The grapes and berries consumed by the ravenous sparrows aggregate thousands of tons annually. In every point in the development of all kinds of crops, from seed-time to harvest, the sparrows became a pest. The branching out in the country has been an important factor in the sparrows' downfall, for it raised up against them the enemies now hounding them to destruction. From their strongholds in the cavities in cliffs and their hiding places in ancient trees, birds of prey fared forth to dispute sovereignty with the invaders. In winter time when food is scarce, the sparrows flock back to the city and thither the raptores have followed them.

It was the shrewd sparrow that first learned that in cities it enjoyed immunity from hunters, but now the hawk has discovered that it, too, may safely venture within municipal lines. The great northern shrike, or butcher bird (*Lanius borealis*), has likewise returned to its attack upon sparrows, and is a powerful ally of the hawks, for it has great powers of mimicry, and has discovered that by imitating the distress call of the sparrow it can summon a flock about it. Thus decoyed, these birds fall easy victims to their lurking enemies. The shrike was a pioneer in the anti-sparrow movement, but like many other forerunners of a great cause it suffered martyrdom. In one large American city, the municipal authorities employed men whose sole duty was to slaughter shrikes, for the belief then was that the sparrow was a blessing to the country and that no enemy should be permitted to wage warfare upon it. In some parts of the United States the bluejay levies upon the eggs and nestlings of the sparrows, and the crow-blackbird or purple grackle has entered the list of adversaries of the alien bird which now all day long, from one end of the year to the other, is beset by powerful foes. At night when hawk and shrike and purple grackle cease from troubling, the omnivorous owl, as has been stated, wings its way to where the sparrows sleep.

All these facts, carefully reported by ornithologists in the field, have been carefully studied, and, as stated in the outset, eminent and conservative experts in this line of investigation now are prepared to prove that the end of the reign of the English sparrow has begun.

Few announcements of scientific men have ever been more enthusiastically welcomed than will be this interesting disclosure that the reign of the English sparrow is menaced. This bird's tyranny in America, Australia, and Europe has hitherto been complete. Conclaves of scientists, legislatures, and even parliaments have repeatedly devised unavailing campaigns against it.

From four to six families are reared annually by a pair of English sparrows. Not infrequently developing nestlings are utilized to hatch subsequent broods. Whatever its faults, this bird is devoted to its young. If one falls from the nest it is not abandoned. This fact led an ornithologist to compute the possible increase from a single pair of birds in ten years, assuming that the first and all successive parents managed to rear twenty-four young annually. The total

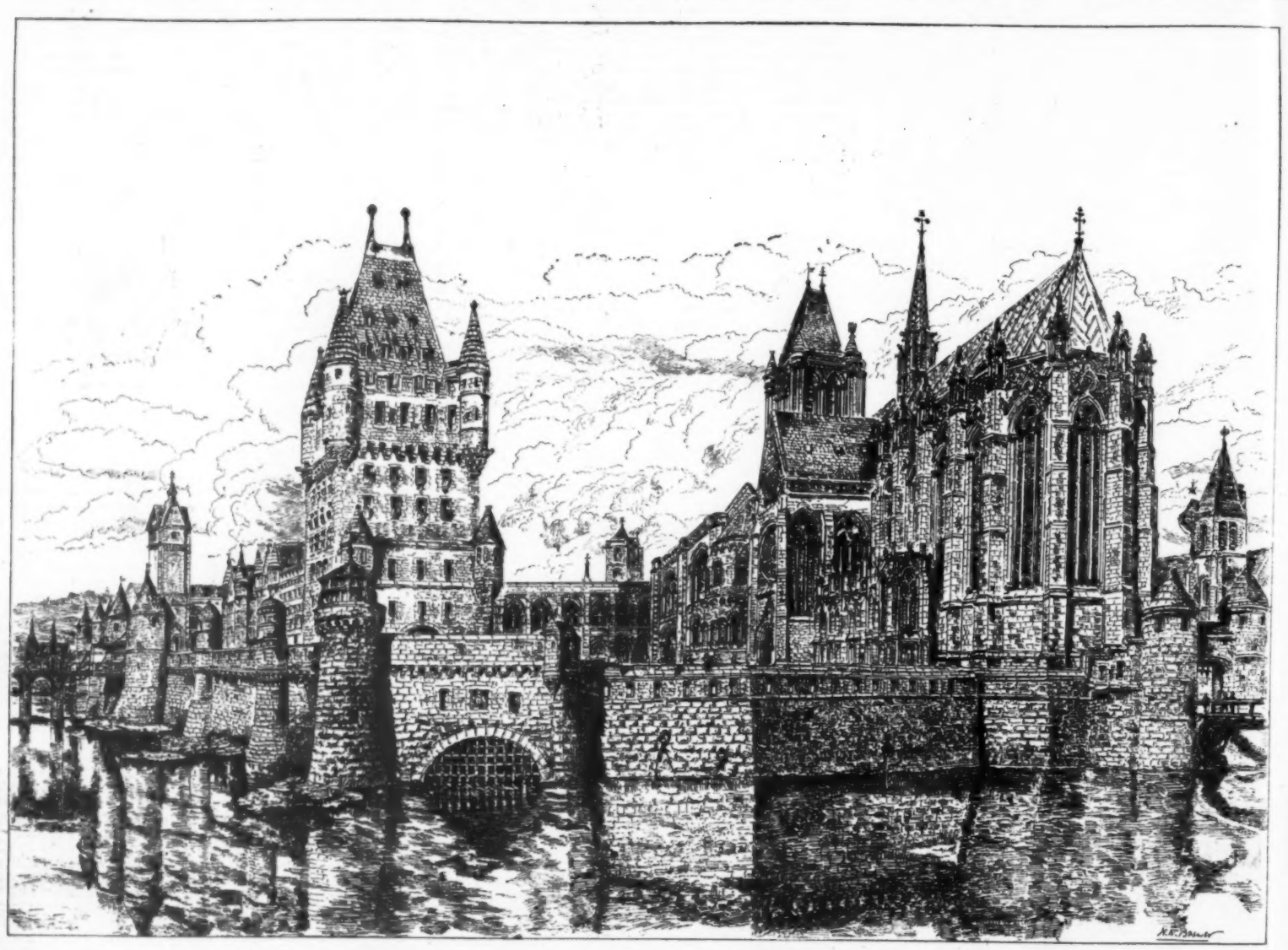
* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

number of birds at the end of the first year would be 26; at the end of the second year, 338; at the end of the third year, 4,394; the fourth, 57,122; the fifth, 742,586; while at the end of the tenth year, calculations revealed that the total number of birds would be 275,716,698.

In the presence of the overwhelming increase of these birds, bounty laws in many States were repealed. In one State containing at least 20,000,000 acres of land affording a congenial habitat for English sparrows, it was estimated that there were at least 40,000,000 of these birds, or two to the acre, which was an exceedingly conservative census. It was pointed out that even if these could all be killed, at a bounty of one cent apiece before any increase would take place, the cost to the State would be $400,000. Obviously, such a quick and wholesale slaughter could not be accomplished. It was shown, moreover, that even under the most sanguine operations of a bounty provision operating for five years against 40,000,000 original sparrows increasing at the lowest conceivable rate, the total cost would exceed $11,000,000.

Manifestly such expensive warfare against the bird could not be carried on. Yet it was evident to economic ornithologists that the damage wrought by the English sparrow exceeded even the most prodigal sums that could be expended in attempts to check its depredations.

With the full realization of the extent of the English sparrow's evil work, the great financial value of the service now rendered by owls and hawks in making exterminating war on these destructive birds becomes apparent.



THE "TEMPLE," PARIS—SCENE OF THE IMPRISONMENT OF LOUIS XVI. AND XVII. (NOW DESTROYED).

DRAWN BY THE LATE H. W. BREWER.

A GREAT ARCHITECTURAL ARTIST.

THE Builder has this to say of one who in his lifetime certainly gave much pleasure to architects on both sides of the Atlantic:

"All readers of the Builder will hear with regret of the death of Mr. H. W. Brewer, which was announced in the Times of a day or two ago. For the space of a quarter of a century he had been one of the most important and original contributors to the illustrated department of this journal, and, though he had a wide reputation, and his work was seen in illustrated journals for general readers, such as the Graphic, among architectural journals his connection has always been solely and entirely with the Builder, for which he produced work of a class which we do not know that any one else can at present supply.

"Mr. Brewer's early contributions to our pages were simply illustrated; chiefly drawings of medieval buildings in Germany, generally selected as rather out of the beaten track of architectural illustration. These he drew on the wood in a most masterly manner (the system of photographing onto the wood had not then come into use); they were noteworthy for the sense of composition and the breadth of light-and-shade effect which characterized them; and they were always cut by one engraver (Heaviside), who understood his work and could make the best of it; and these old engravings from Brewer's drawings have none of that hard, mechanical style of execution which (at this distance of time we may admit) characterized many of our own as well as other illustrative wood-engravings. These impressions in our old volumes afford fine examples of what could be done with the aid of wood-engraving, now unfortunately almost killed by the various forms of processing.

"It was almost simultaneously with the introduction in our illustrative pages of lithography that Mr. Brewer seemed to perceive that there was a wider field for an architectural artist in black-and-white than the mere representation, in however powerful and artistic a manner, of existing monuments. Thenceforth, for our pages at least, he took up one or other of two new lines of illustration; one, the invention of architectural scenes purely with a view to picturesque effect; the other, the restoration in drawing (a wholly innocent form of restoration) of monuments of the past which had disappeared, but for the reconstruction of which a certain degree of documentary evidence could be found. To the first task he brought genius and imagination; to the second, learning and research. One of the first of his pen-drawings for lithography was one which, in picturesque force and poetic feeling, he perhaps never surpassed subsequently—the one entitled 'Deserted,' showing a medieval city, with its cathedral rising in a heap in the center of the composition, the houses clustering round and clinging to it, silent and deserted after a visitation of the plague—not an unknown occurrence in the Middle Ages. Among others of his architectural creations were two contrasted compositions entitled 'Renaissance Gorgeousness' and 'Romanesque Grandeur'; an exceedingly fine picture called 'The Ancient Harbor,' which will be within the recollection of many of our readers; and a remarkable drawing entitled 'Measure and Value,' which was not only an architectural composition, but a critical protest. The drawing represented an immense massive cathedral front, somewhat recalling Peterborough, and the bearings of the title lay in its application—in the implied conclusion that no such building would ever have been erected on the contract system, which Mr. Brewer regarded as being at the bottom of the comparatively weak and feeble character of much modern architecture.

"More numerous, however, than his purely imaginative works were his archæological creations, of which a great number of most remarkable examples are in existence. To this kind of task he brought imagination based on careful research, and he spared no trouble in getting the materials for his restorations. His drawing showing a resuscitation of old St. Peter's at Rome was one of the most remarkable things of the kind ever done; of the value set on it by Roman archæologists, we could judge by the repeated applications which have been made to us to allow of its reproduction in one or another historical publication. Among other remarkable drawings of this class were those of 'London in the Time of Henry VIII.'; Paris at the same period (bird's-eye views or panoramas); 'Medieval Oxford' (also a panorama); another panoramic view of 'Some English Architecture of the Past Fifty Years,' done for the Jubilee number of this journal; 'Old St. Paul's'; 'Nonsuch Palace'; 'Old Cheapside'; 'Aldgate in 1531,' and many others showing the same remarkable union of archæological study with picturesque power. We have in our possession the last two drawings of this class which he made, and which still remain to be published—restorations of two quarters of Old Paris. In our next issue we will give a list of all his works which are to be found in our volumes, with the dates of publication.

"Mr. Brewer was one of the most simple-minded and unassuming of men; more interested in his art for its own sake than for any advantage he could make for himself out of it; and we know that some draughtsmen of architectural subjects far inferior to him in real accomplishment, but who had obtained a more popular repute, obtained terms far beyond what he asked, for work not to be compared to his in real value. From years of out-door sketching in all weathers, he had the weather-beaten appearance suggesting the life of a sailor rather than of an artist; and, though he always appeared to have excellent health, perhaps this exposure shortened his life. He was only sixty-seven when he died."

NEW TRANSFER INK.

THE composition of this ink, which bears the name "economical," is constituted as follows: Printing ink, black or of any color, 1 kilogramme; lard or other fat, 1 kilogramme; mineral pitch, 250 grammes; antiseptic, traces. The different ingredients may, however, be modified according to need.

The mixture is produced cold and in an intimate form by first diluting the pitch with the printing ink, and then incorporating the fat in small successive quantities, until the wished-for consistency is reached.

Any antiseptic substance may be added to render the product imputrescible, and to insure its perfect preservation. The new ink can replace ordinary printing ink in the inkers of machines. It spreads perfectly on the rollers, and the most delicate characters and illustrations are reproduced distinctly. For transferring the impression thus obtained, the inked side is placed on the paper, linen, or other fabric on which the transfer is desired, and then rubbed with a hard polished

body, for example, the back of a spoon, without having recourse to heat. Several distinct copies can thus be obtained.

If a larger number of copies is desired an iron, moderately heated, may be employed; and finally, for an increase in the number of copies, the back of the design may be slightly moistened with benzine or other carbide.—Translated from La Revue des Produits Chimiques.

NEW ROENTGEN RAY APPARATUS.*

WHEN, about the close of the year 1895, Wilhelm Roentgen discovered the light rays which bear his name, science, but more particularly medical science, accepted the revelation as a boon pregnant with big results. Regrettable is it that the hopes, which then sprang suddenly into life, have, in many instances, not materialized. And yet everything connected with Roentgen and his rays—in a word, Roentgen technics—assumed at the time and still holds an important place both in science and industry; and to such an extent is this true that large establishments find it profitable to devote much time and labor to the manufacture of the apparatus.

To conceive of the extent of this industrial activity, one has but to read the book entitled "The Roentgen Technik," written by Dr. Albers-Schoenberg, who, with a number of noted scientists, publishes the periodical Fortschritte, devoted to everything pertaining to the Roentgen rays.

Laymen also could find profit in the reading of this book; for it treats in detail of the interrupter, inductors, resistances, tubes (glass), lead-blind, apparatus for Roentgen geography, the table diaphragm, wall-bracket diaphragm, shade diaphragm, wood-frame diaphragm, compression diaphragm, arrangement of the laboratory, of the dark-room, and the photographic process, and protective devices. To achieve results, it becomes apparent that the man versed in Roentgen technics must surround himself with many and varied utensils. Many things are to be considered—large operating theaters, small laboratories, the physician's ordinary consulting room, the exigencies of war, the requirements of peace; and for each of these proper outfits must be constructed.

There is a constant demand for them because hospitals, infirmaries, military hospitals, private physicians and others in ever-increasing numbers make use of the Roentgen rays. Just now a single Berlin firm—Siemens & Halske—has not less than fifteen different apparatus under construction.

In their huge establishment they have set apart two large saloons especially for the exhibition of Roentgen apparatus.

Recent wars have contributed a great impulse to this industry. Necessities arising from this barbarous game have demonstrated the high value of the Roentgen acquisition, and most conspicuous in the treatment of the wounded. Upon the firing line all energies are directed toward putting the balls in; behind the line, and not always removed to safe distances, the strife is equally as assiduous to get the balls out and repair broken bones. And this unremitting strife to afford the crippled the advantages of the treatment at the earliest possible moment has led to such perfection in the instruments themselves that the apparatus now forms a part of every well-ordered field sanitary train, and to-day the Roentgen rays find application upon the very field of battle itself.

The first essays with this marvelous light were made by the English in India and in the Soudan, and they then became aware of almost insurmountable difficulties in transporting such instruments, entirely suitable under peaceful conditions, but almost useless in war. In later campaigns the military surgeons confined themselves to the employment of several stationary apparatus far removed from the field of action, so that the fallen comrade could only be brought under the searching rays of a Crookes tube some hours after receiving his wound. The German Red Cross Society covered itself with glory and honor when during the Græco-Turkish war and the more recent South African war it established a Roentgen outfit in the hospitals at Constantinople and Jacobsdal; and during the late unpleasantness in China, the German hospital ship and all the field sanitary corps were provided with Roentgen instruments built by Siemens & Halske.

On this occasion the first self-contained transportable apparatus made its appearance. In a special part of the wagon was placed a dynamo driven by a benzine engine to provide the necessary current. Its capacity was that of large sizes used in the laboratory. For the newest instruments which we show in picture, we are also indebted to the Siemens & Halske firm. Fig. 1 depicts a complete Roentgen outfit, arranged to connect to a direct-current circuit carrying from 110 to 220 volts. We see also an inductor which generates a spark, 50 centimeters between points, and the switch table provided with voltmeter and ammeter, with the necessary standard holding the Crookes tube.

To this outfit belongs also an interrupter, which is preferably installed in another room. The so-called Wehnelt interrupter is the one used.

Apparatus for the alternating current are also manufactured, accompanied by the necessary transformer. The most difficult proposition was the construction of the inductor. A spark of 50 centimeters in length is indeed considerable, but it is not the longest. In Fig. 3 we show a regular flame of blue light traversing an air space of one meter (over three feet) from point to point. The transition from single bright sparks to a pencil, sheaf, or flame is effected by the charging. It is the counterpart of the equipment shown in Fig. 2, which is installed in the Roentgen Laboratory of the Royal Institute for Examination by the X-rays in the *Charité* at Berlin.

The contention for this mass of light was so persistent and vigorous that Dr. Albers-Schoenberg says: "One may almost be warranted in dividing the physicians into two parties; the one who clamored for the building of inductors which should give as large sparks as possible, and the others who as stoutly maintained that equally good work could be done with smaller apparatus and sparks of moderate length." However, the great Areopagus of the physicians, the Society of Naturalists and Physicians, decided in 1901 at Hamburg for large inductors, and Dr. Albers-Schoenberg is also inclined that way. Especially for difficult examinations, such as obtaining plates of stone in the kidney, of lumbar vertebræ, of the pelvis, etc., the smaller apparatus are not equal to the occasion, though easier operations may be accomplished and very beautiful illuminations may be obtained with them.

Schoenberg was content with a spark from 50 to 60 centimeters, but as our Fig. 3 shows, it has been wonderfully surpassed. Further details are scarcely necessary for our readers. We beg to call attention, however, to the instrument shown in Fig. 4, which is the compression diaphragm by Dr. Albers-Schoenberg, built for making plates of the more difficult objects, such as structure of the vertebral column, stones in the kidney, etc. This instrument is technically most excellently constructed, it possesses a pliability without equal, and responds to any possible required position; and with the compression cylinder—a lead cylinder of 30 centimeters high—and a slow pressure, the operator is enabled to penetrate almost to the renal cavity.

If the patient lie upon a photographic plate, it is by no means difficult to reduce the distance between the lower opening of the cylinder and the plate by from 5 to 10 centimeters. At this distance softer tubes, giving richer contrast and less diffusion, may be used, and such formations as have a weak absorbability—uric acid stones, for instance—by reason of the softness of the tubes, may be easily shown. Dr. Albers-Schoenberg is of opinion that formations of the size of a pea must under all conditions be visible, and he concludes his observations in a most scientific manner, thus: "We see that the Roentgen diagnosis of kidney stones is a method claiming independence

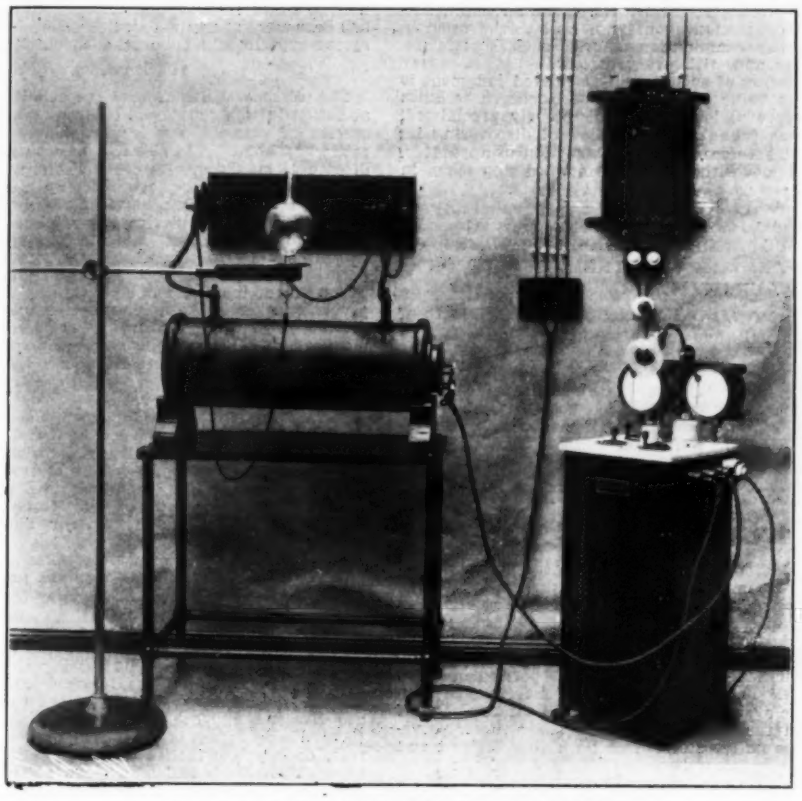


FIG. 1.—A SET OF ROENTGEN APPARATUS.

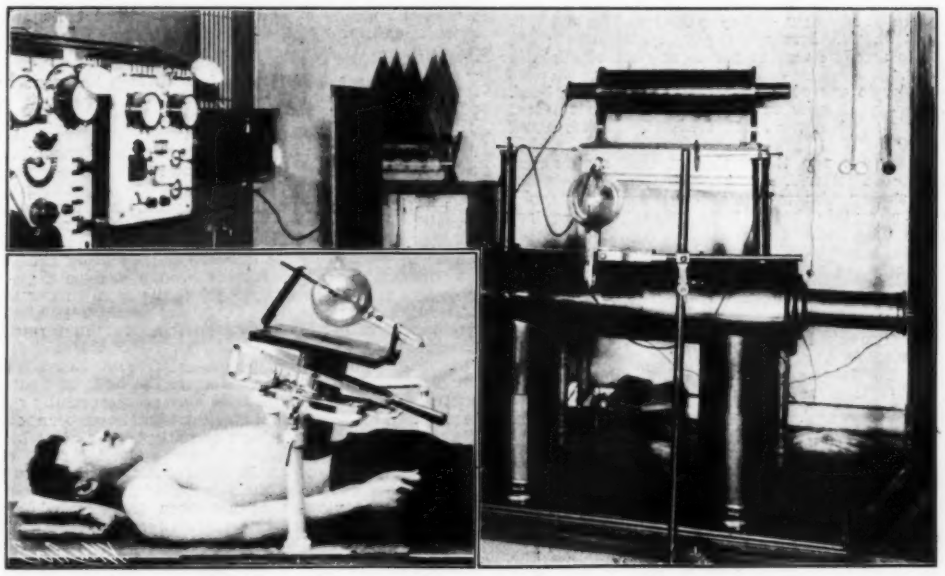


FIG. 4.—CONDENSER OF THE APPARATUS.

FIG. 2.—SPARK COIL OF THE ROENTGEN APPARATUS.

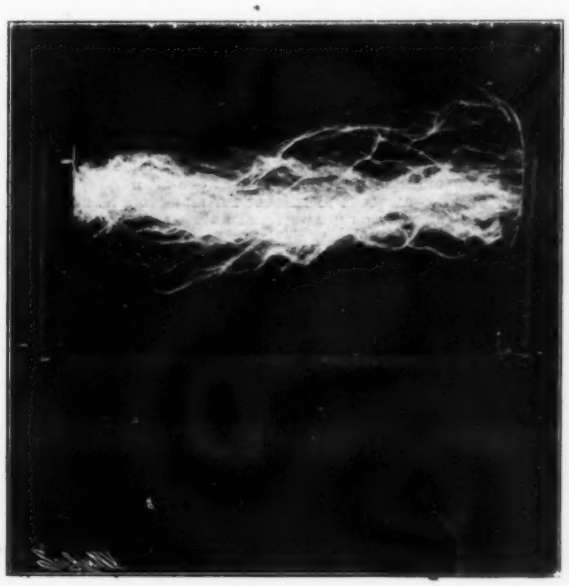


FIG. 3.—A THREE-FOOT SPARK.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

only in part. For this reason then it is eminently ill-timed to base therapeutic measures either solely or even primarily upon the Roentgen findings. Only by the usual clinical procedures can this method receive complementary value. However, the Roentgen method is not to be undervalued on this account, but rather to be considered of such consequence that no patient suspected of having stones in the kidney should escape the X-ray examination. Such cases, in which the diagnosis can be immediately and positively made, are of course the most grateful for the examiner; still, success in this direction should not lead to the assumption that the examination affords such certain results always and with every patient."

The rendering of such a well-considered judgment is of far more value to the cause of Roentgen technics than an approval loudly and boisterously proclaimed. Mankind has found a new method of discovering its ailments. Therefore, in the construction of apparatus, we must follow with zeal every forward step taken in the field.

[Concluded from SUPPLEMENT No. 1456, page 23336.]

INFECTIOUS AND CONTAGIOUS DISEASES OF FARM ANIMALS AND THEIR EFFECT ON AMERICAN AGRICULTURE.*

By D. E. SALMON, D.V.M., Chief of the U. S. Bureau of Animal Industry, Washington, D. C.

TEXAS CATTLE FEVER.

WE have in the United States a disease of cattle which at one time was regarded as most mysterious, but which is now as well understood, owing to the investigations of the Bureau of Animal Industry, as is any of the diseases to which reference has been made. This disease, which we know as Texas fever, exists in various parts of the world, but was first described, so far as I am aware, in the United States, something over a hundred years ago. The great peculiarity of this disease is that it affects nearly all of the cattle in a large area of the southern part of the United States. These cattle apparently do not suffer from it, but if they are brought out of the infected section they spread the disease in a fatal form among other cattle; and if cattle from the non-infected part of the country are taken to the infected section they contract the disease, and if adult they die in the proportion of 70 to 90 per cent. This disease has had a tremendous influence on the agriculture of the South Atlantic and Gulf States. In the first place, it has made the improvement of the native stock of cattle a very difficult and expensive operation, because nearly all of the pure-bred animals taken there for that purpose die within a year of Texas fever. In the second place, it has limited the market and reduced the price of the cattle produced in that section, because the great markets of the country are in the non-infected section, and it is necessary to handle these southern cattle in such a way that they will not disseminate disease among northern cattle.

Under such discouraging conditions, it is not surprising that we find the cattle industry in a rather backward condition in most of the Southern States. Many people there have shown much enterprise, however, in building up herds of good cattle, notwithstanding the losses which they suffered. A large part of the Texas cattle have been bred up to a high degree of excellence as beef-producing animals, and many herds of good cattle are also to be found in the other Gulf States. There was a time, not so many years ago, when Texas fever threatened the prosperity of the cattle industry in our Northern States. Thousands of southern cattle were brought north for feeding, and were sold for slaughter in all of our stockyards. There was no way to discriminate between those which were infectious and those which were not. Cattle cars and stockyards were infected, and the disease was spread everywhere. It was unsafe to buy any cattle in the general markets of the country except for immediate slaughter.

The Bureau of Animal Industry, by its investigations and its inspection service, has greatly changed all of this. We now know exactly the section of country from which the infected cattle come. We also know that the disease is spread by the southern cattle ticks, and that if the cattle are free from these ticks they are not dangerous. The infectious cattle are not allowed to be sold for grazing outside of the infected district except during the cold months, when the tick cannot develop; but such cattle are sent to market for slaughter at all seasons of the year as quarantined animals. They go in cars which are plainly marked "Southern Cattle," and they are unloaded only in yards which are maintained for that class of animals. In this way a market is kept open for the Southern States without endangering the cattle industry of the North. Deaths from Texas fever developing in cattle are now comparatively few, and their influence on the cattle industry is insignificant.

We have, however, accomplished more than this. We have shown that Texas fever is caused by a microscopic animal parasite which lives in the red corpuscles of the blood, and that this parasite lives in two hosts, the bovine animal and the tick. Following up this clew, it was found that several diseases of mankind, notably malaria and yellow fever, are likewise caused by parasites having two hosts, and this knowledge has led to a complete revolution in the measures adopted for the prevention of these diseases. But this line of thought is carrying us away from our subject; nevertheless, something practical for agriculture as well as for medicine has come out of this knowledge. It was shown that the parasite of Texas fever once introduced into the blood of an animal remained there in an active condition during that animal's life, and that the blood of southern animals might be successfully used to inoculate pure bred cattle and render them immune before they were taken to the infected district. This must, of course, be done under certain favorable conditions, but it is a great step in advance, and it enables the stockmen of the South to improve their cattle at much less expense than heretofore.

We have endeavored for years to discover some inexpensive means of destroying the ticks upon the southern cattle without injury to the cattle themselves, but the solution of this problem has been most difficult and evasive. If all of the ticks upon the cattle could with certainty be killed, the animals could then go anywhere without restrictions or danger, and the infected district could be rapidly reduced in size. This would have a very beneficial effect upon the agriculture of that section of the country. Whether we will eventually succeed in this cannot be foretold, but success has been very nearly reached on several occasions, and recent experiments have been encouraging.

TUBERCULOSIS.

The disease which is now especially deserving of attention in this country is tuberculosis. It affects all species of animals, but is particularly common with cattle and hogs. It is also the most common and fatal disease of mankind. Its continued prevalence and increase must have a serious effect upon American agriculture, by diminishing the vigor and productive capacity of our cattle, by destroying valuable breeding animals and blotting out valuable strains of blood, by causing the destruction of many carcasses of beef and pork because unfit for food, and by damaging the reputation of our meat and dairy products. While we are, perhaps, better off with reference to tuberculosis than are most other countries, we nevertheless have far too much of it; and as it causes losses greater than those of most other diseases, there is every reason why we should adopt measures for lessening its spread and for diminishing its frequency.

Tuberculosis has been brought to this country and spread among our live stock very largely through imported pure-bred stock, which was designed to improve the herds and increase the profits of agriculture. It is allowed to remain and propagate itself almost without hindrance in nearly all of our States, because our farmers do not understand its nature and fail to appreciate the damage which it causes.

The time has already arrived when it is extremely difficult to establish a breeding herd representing any one of several of our most popular breeds of cattle without introducing this disease; and the common cattle are becoming involved to such an extent that a dairyman can hardly buy cows in the open market to replenish his herd without getting those which are affected with this disease. Of course, the breeders and dairymen do not advertise the fact that their herds are diseased, and consequently we hear very little of their disappointments and their losses. It is, as a rule, only public institutions which have endeavored to establish herds and which can afford to tell of all that they have suffered from tuberculosis. It may be instructive to recall a few such herds to illustrate the importance of this subject. Soldiers' Home, Washington, D. C., 63 animals, 53 head or 84 per cent tuberculous; Massachusetts Agricultural College, 32 animals, 25 head or 78 per cent tuberculous; New Jersey Agricultural Experiment Station, 42 animals, 25 head or 60 per cent tuberculous; Vermont Agricultural Experiment Station, 33 animals, 21 head or 61 per cent tuberculous; Ohio Agricultural Experiment Station, 30 animals, 14 head or 46 per cent tuberculous; Texas Agricultural Experiment Station, 21 animals, 10 head or 48 per cent tuberculous; Wisconsin Agricultural Experiment Station, 30 animals; 26 head or 86 per cent tuberculous; Kansas Agricultural College, 56 animals, 15 head or 27 per cent tuberculous; Government Hospital for the Insane, Washington, D. C., 102 animals, 79 head or 77 per cent tuberculous; Maine Agricultural Experiment Station, herd so badly diseased that all the animals were slaughtered.

This list could be increased to almost any length desired, but surely it is sufficient for my purpose. If these institutions, with expert assistance, and using public funds, could not keep their herds free from disease, how is the young breeder or the busy dairyman to succeed? It will be noticed that the herds mentioned were widely scattered over the country, and this experience shows, therefore, that the difficulty is not confined to any one section nor to any set of climatic conditions.

In a letter to one of our agricultural journals, Prof. W. A. Henry, director of the Wisconsin Agricultural Experiment Station, gave the following statement of experience:

"Several years ago the writer of this communication received a letter from a good citizen in the State of Iowa, asking him to name some breeder of good cattle of a certain breed from whom the inquirer might purchase some choice stock. As a result this Iowa party came to Wisconsin and purchased seven head of pure-bred stock, paying good prices for them. In taking that stock back to Iowa he carried back tuberculosis in the most virulent form it ever affected a herd in this State. He lost all of the seven animals purchased through death by tuberculosis, and contaminated his whole herd so that he was forced to sacrifice all of the dairy animals he had. And this is but one of more than a dozen places where tuberculosis was spread by sales from a single herd of pure-bred cattle."

This observation made by Prof. Henry is an illustration of what is going on continually in all parts of the country. I recently saw a cow which an enterprising and enthusiastic breeder had paid a large price for, several thousand dollars, by the way, because he wanted that particular strain of blood; and I was told on good authority that when she reached her new home, she was found to be affected with tuberculosis. Now, how can a man afford to put his money into good cattle and endeavor to build up a valuable herd, with such danger, I might almost say with such certainty, of its being sooner or later infected with this insidious and destructive contagion? The fact is, there are comparatively few men trying to breed pure bred animals free from tuberculosis, and the fountain head to which our farmers have been taught to go for improved blood is a source of deterioration and disease.

This may be strong language, but it represents the actual condition of affairs, and unless something is done soon to remedy it the development of our cattle industry will receive a check from which it will not recover for years. The integrity of our meat supply as well as of our dairy products is being threatened. It has been our proud assertion for years that we had the healthiest animals and produced meat the freest from disease of any in the world. Are we going to allow ourselves to drift into the same distressing condition, in this respect, that is seen in European countries? The federal meat-inspection statistics, which cover five to six million cattle and twenty-five million hogs a year, show that the condemnations for tuberculosis are increasing from year to year at a rate that must cause anxiety to every one interested in American agriculture.

In an effort to attract the attention of our people to this important subject, and to stem the tide of tuberculous animals that has been pouring into this country from abroad, the Department of Agriculture has prohibited such diseased animals and provided that all imported cattle should be tested. The testing of these cattle offered for importation has proved that many of the foreign herds are so diseased that they are absolutely unfit to furnish breeding animals; and this notwithstanding the fact that there has been much trickery on the part of the breeders, and dosing with tuberculin and other drugs to prevent a successful test.

What is needed is an effort all along the line to prevent the importation of diseased cattle and to eradicate tuberculosis from our own herds. Above all, it is important that our pure-bred herds should be put into a condition to supply animals that are healthy and that will improve the common herds into which they are taken.

There has been much said during the last three or four years concerning the relation between human and bovine tuberculosis. While, as I have shown, the effect of this disease upon the animal industry is so disastrous that it should be suppressed for economic reasons alone, its danger to human health is another and equally strong reason why such action should be taken. It is only two years since a great authority on tuberculosis proclaimed in the London Congress on Tuberculosis that the tuberculosis of man could not be transferred to cattle and that the tuberculosis of cattle was not transmissible to man. That doctrine is already discredited and absolutely disproved by the experiments of many investigators. Indeed, the very commission which was appointed by the German government at the request of Koch, and which has shown its bias in his favor, has made a report which demonstrates not only that human tuberculosis may be communicated to cattle, but that by their most conclusive test, 25 per cent of the tuberculosis of children which they investigated was of bovine origin. It is unnecessary to dwell upon this fact. The farmer's family should be protected from tuberculosis no less than his cattle.

SCABIES OF SHEEP.

The scabies or scab of sheep is a disease which has been an incubus upon the sheep industry for many years. It has prevented the infected flocks from thriving; it has caused a great loss of wool; it has weakened the animals so that they were unable to withstand the cold, exposure, and other hardships of winter, and it has checked and discouraged the development of the industry. It has been particularly severe on the western ranges, and the marketing of diseased animals thoroughly infected the sheep cars and stockyards. In order to control this disease the department has prohibited the shipment of diseased animals from one State to another, and is co-operating with a number of States for the suppression of the pest. There is no disease which may be cured more easily, more certainly, or with less expense; and the result of the work has been to greatly lessen the prevalence of the disease. To make this improvement permanent, we are taking groups of States, as many as can be handled at a time, and are stamping out the disease in the whole section. We expect in this way to clean up the sheep-raising country and in the course of a few years to entirely eradicate the disease. This will greatly increase the profits of sheep husbandry, and make it a more certain and stable business.

HOG CHOLERA.

The one disease of farm animals which has gone on unchecked, and which has baffled us in our efforts to develop a plan of campaign that would seem to promise success, is hog cholera. The average loss from this disease is probably not less than fifty million dollars a year. It ruins many farmers, and it makes our pork cost more than it ought to produce it. But nevertheless we have an abundance of pork, and the losses from the disease are accepted as one of those inevitable things which cannot be escaped. The time is coming, however, when with the increase of population and the limiting of the corn-producing area it will be a great object to save the hogs which now die from this cause. Indeed, this fifty millions of dollars would even at the present be a most welcome addition to the farmers' income.

I have not time to say more relative to this subject than that we have never given up the hope of finding a means by which this disease may be successfully controlled. The scientific investigations have been continued, and discoveries have recently been made which explain some of our past failures and offer some encouragement to expect better results in the future. This disease is one of the most difficult, from a scientific point of view, that has been investigated, and much time is required to establish facts concerning its nature even when the method of research that should be used has been made clear.

BLACKLEG.

A disease of cattle prevails in many sections of the country which is known as blackleg or symptomatic anthrax. In some districts it has destroyed from 10 to 20 per cent of the young cattle and almost prevented the production of bovine animals. Some years ago the department introduced a vaccine for this plague which has been so successful as to reduce the losses to about one-half of one per cent. More than 1,688,000 doses of this vaccine were distributed last year, and we have reason to believe that nearly all of this was used. There is here a very large saving which has been brought about by scientific investigation and by the intelligent application of proper methods of prevention.

* Read at the Farmers' National Congress, Niagara Falls, N. Y., September 23, 1903.

There are a number of other contagious diseases of animals, such as glanders, anthrax, and rabies, which have considerable influence upon agriculture, but which I shall not discuss at this time. What I wish to impress upon you is that as the number of animals in a country increases, as the transportation facilities improve, as the traffic in live-stock becomes more brisk, the danger from communicable diseases increases and the necessity for official control becomes more urgent. To control such diseases in a great country like the United States is an undertaking of magnitude which must have the earnest and cordial support of the farmers to insure success.

There are a number of ways in which the communicable diseases of farm animals affect agriculture, and in order that these may be clearly placed before you I have recapitulated them as follows:

1. By the direct loss of the affected animals.
2. By loss of business on account of an outbreak of disease, as usually occurs when dairies are affected.
3. By the expense of treating the animals and disinfecting the premises.
4. By quarantines and other restrictions.
5. By the reduction of value of individual and product in the case of animals which live.
6. By the destruction of valuable breeding animals and by checking the improvement of breeds.
7. By the loss of markets which are closed to countries in which certain diseases exist.

INFLUENCES OF THE SUNSPOTS UPON ELECTRICAL AND MAGNETIC FORCES OF THE EARTH.*

By WILLIAM FINN.

SEVERAL plausible theories are advanced by scientists to account for these strange and mysterious influences which operate upon the electrical and magnetic forces of the earth. It has been proved by the result of careful observations made upon the electrical condition of the earth that the air is always more or less charged with electricity, so that the earth may be regarded as a highly-electrified sphere with electrostatic lines of induction radiating from it in all directions into space. It may be accepted as highly probable that the sun and other planets in the solar system are similarly charged to a greater or lesser extent; and that between all planetary bodies an electric force is exerted which varies with their respective charges and the distances separating them. Since any alteration in the static distribution of electricity upon a conductor will set up an electric current in it, so in this case, the earth in its motion relative to the sun will have its electricity constantly in motion, thus giving rise to electric currents.

Under ordinary conditions these currents would undergo regular periodic changes corresponding with the variations in the relative densities and distances between the charged bodies; but under exceptional circumstances when great and sudden changes are occurring in the solar atmosphere there will be sympathetic fluctuations in the magnetic field between the earth and sun which would create the conditions requisite for the generation of strong and variable earth currents.

These earth currents are mainly due to the magnetic force of the sun; and the singularly erratic performances of an electrical character, such as have been noted in periods of greatest disturbances to our telegraphic system, are more prevalent during the period of the maximum sunspots than at any other time. In this connection it is a singular fact that the wires proceeding north and south are not so much excited in

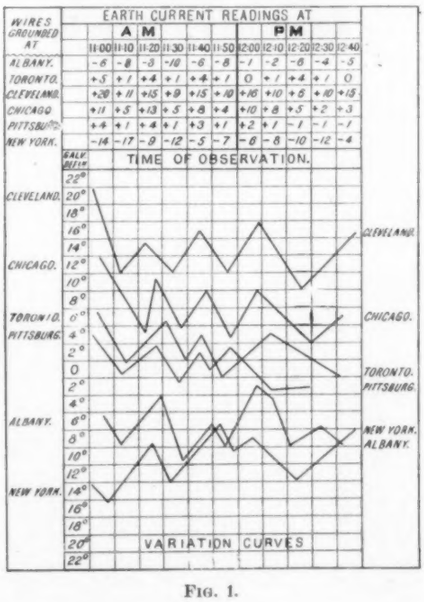

EARTH CURRENT READINGS AT
WIRES GROUNDED AT
A M
P M
11·00 11·10 11·20 11·30 11·40 11·50 12·00 12·10 12·20 12·30 12·40
ALBANY. - 6 - 8 - 3 - 10 - 6 - 8 - 1 - 2 - 6 - 4 - 5
TORONTO. + 5 + 1 + 4 + 1 + 4 + 1 0 + 1 + 4 + 1 0
CLEVELAND. + 20 + 11 + 15 + 9 + 15 + 10 + 16 + 10 + 6 + 10 + 15
CHICAGO. + 11 + 5 + 13 + 5 + 8 + 4 + 10 + 8 + 5 + 2 + 3
PITTSBURG. + 4 + 1 + 4 + 1 + 3 + 1 + 2 + 1 - 1 - 1 - 1
NEW YORK. - 14 - 17 - 9 - 12 - 5 - 7 - 6 - 8 - 10 - 12 - 4
GALV. DEFLN.
TIME OF OBSERVATION.
CLEVELAND.
CHICAGO.
TORONTO.
PITTSBURG.
ALBANY.
NEW YORK.
CLEVELAND.
CHICAGO.
TORONTO. PITTSBURG.
NEW YORK. ALBANY.
VARIATION CURVES

FIG. 1.

periods of these electrical disturbances as those extending in other directions.

To make this statement perfectly clear, let us consider what happens when a stone is dropped into a pool of water. The waves in circular form as they proceed outward from a disturbed center are alternately depressed and elevated. Any particle forming a portion of one of these waves is a part of the circle of particles at the same height as itself and equally distant from the center of the disturbance. Between any two points on this circle, therefore, there will be no tendency for water to flow. Moreover, it is also evident that the disturbing force acts across these circles in a direction perpendicular to their surfaces.

Equipotential surfaces or surfaces of equal electrical pressure may be likened to the series of concentric circles set up by the water disturbance above stated. A body electrically excited may, in fact, be regarded as a center of disturbance from which lines of electrical force radiate in all directions. At any distance from the center a circle may be drawn, all points of which being equally distant from the center, will be at the same electric potential or level.

Circles so described represent an equipotential surface along which there will be no tendency for electric-

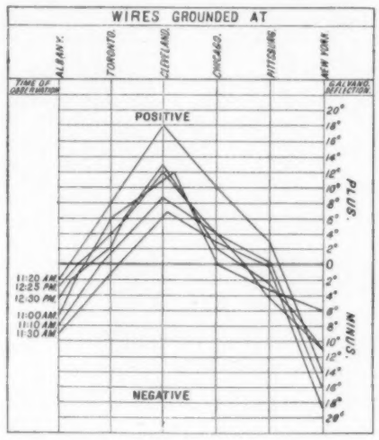


FIG. 2.

ity to flow. These facts explain why in certain electrical disturbances such as we have recently experienced no disturbing influence has been felt at some points while in others the telegraph lines have been demoralized for hours. Since electric forces always act across, or at right angles to the electrical pressure surfaces, it is possible to mark the direction taken by the propagating force and to even trace it to its origin. In this way it has been positively demonstrated that the sun is mainly responsible for the phenomena noted.

There are other currents of natural electricity which may be found in any telegraph wire at almost any time that are the very antitheses of the intense and fitful currents we have just been considering. These are the normal earth currents which differ from the abnormal ones in several particulars. They are not transient visitors like these unusual disturbances but permanent residents in the earth. They are very much less intense and variable, show greater regularity in their fluctuations and appear to be controlled by the same invariable and general law. Early investigations show that these currents ebb and flow in a manner like the tides of the ocean, which confirms the belief that their cause is due to the action of the moon.

Readings made on the Atlantic cables every fifteen minutes for thirty-six hours and compared with tidal movements indicated the closest possible connection between the variations of the earth current and the periods of high and low water marks. This result is in accord with the theory that as the tides are due to the influence of the moon's attraction for the waters of the earth, the relative positions of the earth and moon determining the times and places of low and high water; so in very much the same way may the moon affect the flow and ebb of the earth's electric currents.

The earth is surrounded by what may be regarded as an atmosphere of electricity which acts inductively upon the combined electricities in the earth, and attracts or raises toward its surface the electricity of opposite name to that contained in the atmosphere. The aerial electricity is reacted upon by the opposite charge in the ground, and so long as this condition of stress is maintained between them the opposing electricities remain quiescent and impotent like the electrical charge in a condenser. But when from any cause this strain is removed, the earth's electricity which has been lifted to a higher level, as it were, rushes back to its original level in the form of an earth current. Whenever, therefore, the aerial charge becomes electrically excited, corresponding effects take place in the ground, through which currents of electricity flow whose magnitude and intensity will depend upon the nature and extent of the original inductive disturbance.

Now imagine one of these tremendous convulsions to be taking place in the sun with its accompanying electrical manifestations, which—judging from terrestrial analogies—may be properly assumed to be one of the characteristics of solar eruptions. The disturbance produced would be communicated to the ether, and by it transmitted like the waves of light—and at about the same velocity—until it reached our electrically enveloped sphere. Undulations or waves would then be started in the electrical atmosphere, which would induce corresponding impulses in the electricity of the earth, causing electrical waves or earth currents to travel through the earth and to enter the telegraph wires by means of their ground connections. During the prevalence of earth currents the surface of the globe is forced to be divided up into a series of equipotential planes or electrical pressure surfaces which may be roughly likened to the meridian lines drawn upon a map. Along any one of these planes the electric pressure is always the same at the same time, but between neighboring planes a difference of potential always exists. It is along lines of force running across these planes that the greatest interruptions are invariably felt.

The magnitude of the forces developed in the wires evidently bears some relation to the length of the circuit and experience shows that the maximum potential difference exists as a rule between the terminal grounds of our longest wires. During an electrical disturbance in 1891 similar to that through which we have just passed an electromotive force of 768 volts was recorded on the Western Union lines between New York and Buffalo, the circuits varying from 450 to 480 miles in length. On several occasions the strength of the earth current reached nearly 300 milliamperes. The average strength of the working currents does not exceed 35 milliamperes.

I notice a report made by Supt. Green, of the Northern Pacific Railroad service, in which he worked a line from St. Paul, Minn., to Dickinson, N. Dak., a distance of 650 miles, simply by the electricity taken from the atmosphere during the aurora borealis on Saturday, October 31 last. The strength of this current registered 23 millimeters positive back to the same figure negative.

Several interesting experiments were made by me in England a number of years ago and continued while in Buffalo, N. Y., in which I was able to test the polarity and strength of the current on each wire carefully and simultaneously once every hour for a certain length of time, the readings being reproduced in the form of curves which very clearly demonstrate the course taken by the current across the earth. In making these observations I discovered a current of ten times the sufficient power to operate our duplex and quadruplex systems.

One of the most interesting features of my observations along this line of investigation is the possibility of determining through the variations in these ground currents the approach of severe storms, earthquakes, the warning of danger in volcanic regions, and such other disturbances which will make their advent to be feared even when first felt in remote quarters. In this way the cables have given warnings of severe storms at sea long before their presence was noted on land, and sailors on incoming vessels have confirmed their severity. The last great electrical display of the aurora borealis gave signs of its coming days in advance, and more severe results are to be anticipated from the continued and increasing disturbances on the sun.

It is customary in the British telegraph service for wire chiefs to note particularly the period and extent of abnormal earth currents at all points where observations can be made without interfering with the regular service, and the data thus obtained is forwarded to London, where it is analyzed, plotted when necessary, and the results made public. The use of the "closed circuit" system in vogue in America is one of the difficulties of following such a course here, but it would be possible to take note of the circuits that are not affected by the disturbing forces, for the direction of such circuits would mark the *force course* of the equipotential or electrical pressure lines which are always at right angles to the path taken by the disturbing elements.

A systematic map of observation at places widely apart would render possible the construction of a map of the world or certain sections thereof, showing the places through which the equipotential lines pass during times of periodic disturbances of solar, lunar or terrestrial origin. The curves thus drawn might prove as advantageous in their way to telegraphy and weather forecasts as the isobar and isothermal lines have proved useful to meteorology or the isogonic curves in navigation.

The general phenomena of earth currents are but imperfectly understood at present, but their effects are so universal and so important to science that it does not require an extraordinary stretch of imagination to conceive the possibility of an extended application of these currents to useful purposes at some future time.

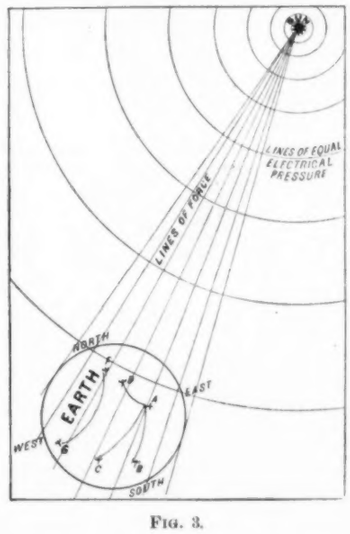


FIG. 3.

With such a prospect before us, and in view of the remarkable applications of electricity in recent times, why may we not indulge the hope that further study and investigation may yet evolve consequences that cannot even be suspected at the present time?

The accompanying diagram roughly illustrates the manner in which an electrical disturbance may be supposed to be propagated from the sun to the earth.

The disturbing force gives rise to a series of electrical impulses which are transmitted in all directions through space in the form of spherical waves (growing larger as they extend outward from the sun as the water waves increase from the center of a disturbance on its surface) which develop upon the surface of the earth those lines of equal pressure or potential

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

represented in the drawing as circles or portions thereof.

The electric force, like many others, diminishes with distance according to the law of inverse squares, but the value of the force at a given point on any one of the circles is the same as at all other points on the same circle because they are equally distant from the center of disturbance. Hence the circle represents an equipotential surface along which the natural forces are inactive. All other surfaces, however, will necessarily have different values, and therefore the inequality of potential exists which tends to create an electro-motive force in any telegraph wire connecting the various circles. It is this difference in potentials which drives the electricity through the wire.

The straight lines radiating from the sun represent the lines of electric force along which the earth currents are impelled with the greatest velocity. Telegraph circuits that run along these lines of force, such as *A B* and *F G*, are the ones most strongly affected. Circuits that cut the equipotential circles or lines of electrical pressure at other than right angle, as *A C*, are not so seriously troubled, while those wires terminating on any part of an equipotential surface as *A D* are absolutely free from interruption.

The curves in the earth currents as shown in Figs. 1 and 2, are the results of readings taken at intervals of every ten minutes for a specified time on certain telegraph circuits. The coincidence apparent in the variation curves (Fig. 1) is sufficiently marked to indicate the undulatory character of the earth current over the sections tested at the time of observation. The direction force curves (Fig. 2) are obtained by reproducing the figures as read down the column instead of from left to right as in the previous case and show the definite direction taken by the current. This direction is from Cleveland, the point showing the strongest positive reading, toward New York, the strong negative point. The line of least intensity is between Toronto and Pittsburg, or nearly north and south, which was in a direction at right angles to the easterly and westerly course of the maximum currents.

FIG. 1.—RUBBER COAGULATED BY JUICE OF MOON-VINE.

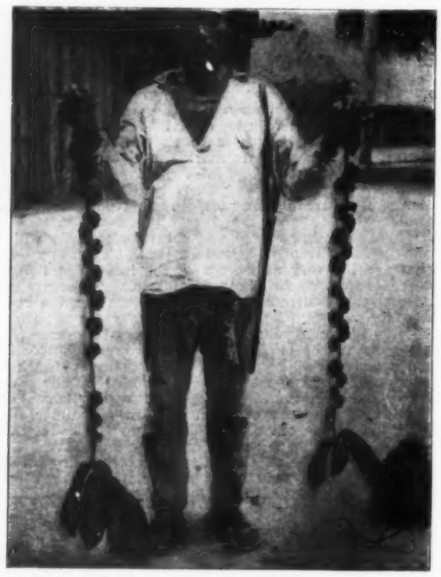


FIG. 2.—BRANCHES OF CASTILLA WITH RIPE FRUIT.

FIG. 3.—BASE OF TREE INJURED BY TAPPING.

[Concluded from SUPPLEMENT No. 1456, page 23334.]

THE CENTRAL AMERICAN RUBBER TREE.*

INVESTIGATIONS AND EXPERIMENTS.

By O. F. COOK.

DIRECTION and Shape of Incisions.—The tubes which produce the milk of Castilla and other rubber trees are so slender and thread-like that the creamy liquid would not flow from their cut ends if it were not forced out by pressure. Some writers seem to have assumed that the liquid is actually compressed inside the tubes, or that the walls of the tubes are stretched by the liquid they take up. A more probable view is that recently advocated by M. Lecomte,† that the pressure is due to the tension of the bark, and that it is mostly exerted in a transverse direction. If we add to this the fact that nearly all the tubes extend lengthwise, a transverse cut would reach the maximum number of these and would thus for two important reasons secure more milk than one of the same length in any other direction. A cut along the trunk would be the worst, since it would reach the fewest tubes and relieve the tension of the bark most. Oblique cuts are intermediate, the more horizontal the better. M. Lecomte hesitates to recommend transverse cuts lest they may prove injurious to the tree; but if a short transverse cut will bring as much milk as a longer oblique gash there seems to be no real reason why it should be more harmful, provided, of course, the tree be not girdled, or too much bark be not cut away at one level. The practical difficulty with transverse cuts lies in the fact that it would be much more difficult to collect the milk, some of which will stay in the cuts, while the surplus will run down the trunk of the tree in many driblets instead of being brought together at the point of the V-shaped incisions generally used. The desirability of making the cuts as nearly transverse as possible should, however, be considered, and in districts where, as in eastern Guatemala, dependence is placed entirely on the "scrap" rubber, most of which coagulates in the cuts or on the surface of the trunk of the tree, it may be feasible to make the cuts nearly or quite transverse. Indeed, this is what Dr. Preuss describes as customary on El Baul plantation in Guatemala:

"For tapping they use an instrument made out of a bush knife (machete). The end of the blade is for this purpose bent back until a groove is formed about broad enough to lay a finger in. The cutting edge of this groove is well sharpened. With this instrument the workmen tear *horizontal* gashes in the bark of the trees, and indeed over a half or three-quarters of the circumference of the trunk. The grooves are cut at distances of 1½ feet, one above another, up to the principal branches. The milk at first flows out in drops, which fall to the ground. They let these go to waste because the quantity is only small and this milk is very watery. But in a minute or two the dropping ceases and the milk which then oozes out is pulpy and remains in the furrows, where it hardens into strips of rubber. In two days these strips are pulled out, washed, and dried in the shade, and are then ready for market. Drying in the sun causes the rubber to become sticky and should be strictly avoided. The trees are tapped four times a year; each time another side of the trunk is operated on. The yield each time is half a pound of rubber, or one kilogramme (2.2 pounds) in a year. I was informed that the horizontal grooves made with the instrument described require only a quarter as much time to fill up as the broad diagonal wounds made with the machete. The former are completely closed in three months' time, and the tree recovers very rapidly."

Parkin's experiments in tapping Hevea in Ceylon gave results much in favor of oblique incisions over horizontal or vertical. He says:

"In both cases the oblique incision yields about double that of the other. There seems little difference between the amount collectible from a vertical and a horizontal incision. Although there is a greater output of latex from the horizontal cut, yet much more dries on the wound than in the case of the vertical, consequently the amount which drops into the receiver comes to about the same in the two cases."*

With Hevea it was found that two oblique incisions joined below to make a letter V gave nearly twice as much latex as one alone. In case of Castilla, however, where the milk flows so much more freely, it was concluded that the most milk could be secured with the least injury to the tree by means of separate oblique incisions. Such cuts would certainly heal more readily than V-shaped wounds, since the bark frequently receives its worst injuries at the junction of the two incisions.

Tapping Instruments.—That improved methods and tools are to be used for cultivated trees is one of the points on which all the rubber planters agree, but as yet none of the many improvements suggested has attained any popularity, and it is at least doubtful whether any of the devices brought forward at this time is to be looked upon as a practical solution of the problem. Some inventors have worked on the erroneous idea that the rubber comes from the sap, like sugar from the maple, and have thus completely wasted their time.

An enumeration of some of the features essential for a good tapping instrument may save further labor on wrong lines.

The cutting edge must be keen, and must therefore be easy to sharpen. A thick or blunt edge bruises the wood and milk tubes, and this interferes with the flow of milk.

There should be a means by which the depth of the cut can be regulated, since it is important to cut deep enough to reach the milk and yet not so deep as to reach into the wood, but axes and chisels with shoulders to prevent too deep penetration are not promising because the thickness of the outer bark is variable. The shoulders also bruise the bark if the cutting is by blows. In British India it is thought that the best instrument for tapping the Para rubber trees is an ordinary carpenter's gouge.

Multiple Tapping.—By far the most important recent discovery in connection with the culture of Para rubber in the East Indies is what may be called multiple tapping, or the repeated cutting of the edges of the wound to induce a renewed flow of milk. This is, it is true, by no means a new idea, since it seems to have been the regular practice of the rubber gatherers of Brazil; but their idea that the tree gave more milk after it had become accustomed to the operation seemed so childishly fanciful to Europeans that it has only recently been put to a practical test, and now there is much surprise to find that it is very decidedly correct. Perhaps the most striking instance is that described very recently from Selangor, where a single Para rubber tree 25 years old yielded 18 pounds of rubber in a period of two months.* A single ounce was obtained the first day, and 1½ pounds in the next five days. For 10 days the daily average was more than half a pound, and on the twelfth day a maximum of 12 ounces was obtained. A second tree yielded a total of 12 pounds 10 ounces of rubber. It was estimated that about seventy hours of labor was required to collect about 30 pounds of rubber from the two trees, or over two hours for each pound of rubber, which may be noted as an indication that the collection of rubber by this method will be expensive in proportion as it is carefully done, since it will require intelligent and somewhat skillful cutting to avoid too serious injury to the trees.

Protection Against Thieves.—A serious obstacle to profitable rubber culture in some parts of Central America is the stealing of the milk by the natives, and especially by those who have been accustomed to make a living from the tapping of the wild trees. Trouble from this source is likely to be much worse in countries where rubber is a natural product than in regions where the natives have not been accustomed to gather and sell it, and where no recognized trade exists to make easy the marketing of the contraband product. According to Dr. Carl Sapper,† long a resident of Central America and widely acquainted with social and agricultural conditions, many landowners have given up rubber culture because they find themselves unable to guard their trees from thieves who do not even wait to rob them of their crop, but destroy the young trees as soon as they begin to produce. A similar report is current from the banana-growing districts of the eastern seaboard of Central America, where experiments in rubber culture are said to have been given up not because the trees failed to grow but because the planters found that they would be unable to harvest their crop. In the West Indies and in many other tropical countries it has been found difficult to grow fruits and other food crops in proximity to a lawless native population, but rubber is even more difficult to protect, because of its high value, its continued presence in the tree, the ease with which it can be taken, the long time it can be stored, its small bulk, and the facility with which it can be transported and marketed.

These facts will increase the hazard of many rubber investments and will render obvious the advantage of enterprises operated in settled communities and protected by stable and responsible governments, for in the waiting period of eight or ten years many vicissitudes may be encountered. The ease and profit with which a rubber plantation could be plundered would be equaled only by the havoc which would result from reckless depredation.

To meet ordinary needs of protection two expedients may be suggested. In countries which are anxious to encourage the preservation and planting of rubber others than landowners and planters could be prohibited from marketing crude rubber or from having it in their possession, merchants being compelled to account for their exports by purchase from such authorized persons. On the other hand, the use by planters of special tapping tools not obtainable by the natives would make it possible to detect the theft

* From Bulletin 40 of the Bureau of Plant Industry, Department of Agriculture.

† Journ. d'Agri. Tropicale, 10:100. Translated in Agricultural Bulletin of the Straits and Federated Malay States, 1:282.

* Circular Royal Botanic Gardens, Ceylon, June, 1899, p. 121.

* Agricultural Bulletin of the Straits and Federated Malay States, 1:556, November, 1902.

† Der Tropenpflanzer, 3:585, 1899.

of rubber, which is now extremely difficult. Indeed, the estates are often robbed by their own employes, and the rubber sold from "our own trees" by some of the companies is said to be purchased from thieves who save the owners the trouble of gathering their rubber.

The problem of rubber gathering is thus a real one which should be attacked with vigor and persistence. Not only are the present Central American methods quite unsuitable for use with cultivated trees, but there is a scarcity, and in many districts a complete absence of laborers capable of applying even the present barbarous treatment. If their cultural efforts should prove successful it will be but a few years when plantation managers who have set out trees by the hundreds of thousands may find themselves unable to extract the liquid wealth. The temptation will then be great to end the tedious waiting for results by turning the plantations over to the mercies of the "huleros," if, indeed, it be found practicable to prevent them from helping themselves.

METHODS OF COAGULATING THE LATEX OF CASTILLA.

Coagulation by Creaming.—The separation of rubber from the latex, a process commonly called coagulation, is in a somewhat more advanced state of investigation than the subject of tapping, if, indeed, the recent experiments of Dr. Weber do not mean that a final and satisfactory conclusion has been reached. Dr. Weber finds that by the simple expedient of diluting the fresh latex of Castilla with five times its volume of boiling water and adding 8 ounces of formaldehyde to each barrel of the resulting fluid, all the impurities to which the inferiority of Castilla rubber is due can be removed, since they will remain in solution, while after twenty-four hours the clean rubber will be found in a "snow-white cake" which can be lifted off the top. Dr. Weber contends that rubber prepared in this way is "absolutely free from solid impurities of any description, . . . either soluble or insoluble, organic or inorganic," and that it is equal or superior to the finest brands of Para rubber. The process is simple and inexpensive, and if the mechanical qualities of the rubber meet Dr. Weber's expectations when the practical tests of manufacturing have been applied, it would seem that the essential requirements of the problem have been met, and in any case valuable progress has been made. It seems, moreover, from the investigations made by Parkin in Ceylon that this method is capable of still further simplification.

"When the latex of Castilla is mixed with water and allowed to stand, in the course of an hour or two the caoutchouc particles have all floated to the top in the form of a thick cream. The diluted latex of Hevea, on the contrary, shows no signs of creaming, even when submitted to a low temperature. The difference is most likely due to the larger size of the caoutchouc globule in the case of Castilla as compared with that of Hevea."*

Parkin found, however, an interesting difference between the latex of Castilla in Ceylon and that described from tropical America by Biffen, in whose results Weber may be said to acquiesce, since he holds that the albumens of Castilla latex are readily coagulated by alkaline solutions.

"The proteid of the latex of *Castilla elastica* has also been investigated to some extent by Biffen. He found that the latex gives an acid reaction, and that on the addition of a little alkali it is coagulated. This he considered to be due to the nature of the proteid which exists as acid albumen in the latex; on neutralization it comes out of solution and gathers together the caoutchouc particles into clots.

"Now, the latex of the Castilla introduced into Ceylon (*C. markhamiana*) does not behave like this. On the very gradual addition of alkali to the latex or to the filtrate (the liquid part of the latex without the globules of caoutchouc) no coagulation or precipitation occurs. Alcohol causes a coagulation of the latex and a copious precipitate in the filtrate, which is quite soluble again in water. Proteid is present in considerable quantity, about 4 per cent being indicated by analysis. Coagulation is brought about neither by acids nor by boiling. Thus it looks as if the proteid belongs to the class of albumoses. At any rate the type of Castilla introduced into Ceylon differs in this respect strikingly from that of the true *Castilla elastica* examined by Biffen."

These facts are of interest, not only from their bearing upon coagulation and function of latex, but because they indicate the extent to which the latex and its constituents may vary under different conditions of growth. Parkin is probably in error in the idea that the latex with which he experimented belonged to *Castilla markhamiana*. The tree which was introduced by Cross from Panama to Ceylon is more likely to be the same as that with which Weber experimented in Colombia.

Discoloration of Castilla Latex.—Incidental to his principal discovery, Dr. Weber reports several observations of much interest, not alone in their practical significance, but also as illustrations of the mistakes which can be made in a subject so difficult of investigation as rubber. Thus it is found that the milk of Castilla contains not a trace of tannic acid, the presence of which has often been inferred, presumably because ferric chloride produces the same color reaction with latex as with tannic acid, turning it dark green. This reaction Dr. Weber finds to be due to the presence of a glucoside, which also gives the latex its intensely bitter taste. The addition of tannic acid precipitates the albumens of the latex, so that the presence of albumens is itself deemed a sufficient evidence of the absence of tannic acid in latex of any kind.

The rapid color change of the milk of Castilla on exposure to the air is found to be due to an enzyme or oxidizing ferment (oxidase), which is probably destroyed by the boiling water, as suggested by Parkin, to whose work Dr. Weber does not refer, although in this part of the subject it had covered the same ground.

Parkin reported as follows:

"Several latices, which are pure white when they first issue from a wound on the plant, rapidly darken on exposure to the air. This is due to the presence of an oxidizing ferment, or oxidase, which with the aid of the oxygen of the air acts on some constituent of the latex, changing it to a deep brown coloring matter.

"The latex of Castilla is a good example. It rapidly darkens on exposure and dries to an almost black rubber. By creaming the caoutchouc particles can be separated from the dark beer-like liquid and made into a sheet of nearly colorless rubber. By quickly heating the collected latex the darkening is arrested, owing to the destruction of the enzyme.

"The latex of Hevea collected from the tree trunk does not darken at all on exposure to the air, and, provided that molds and putrefactive organisms are kept away, rubber prepared from it remains indefinitely of a light color. On the other hand, the latex from the wall of the unripe capsule (fruit) changes on exposure from milk-white to black. The darkening is wholly prevented if the latex is quickly subjected to heat. No doubt there is an oxidase present in the latex of the capsule."*

The expression "coagulation of rubber" appears objectionable to Dr. Weber, because he finds that it is the albuminous substances of the latex which coagulate and not the rubber itself, but this objection seems rather overtechnical, since, even in Dr. Weber's method, the rubber is collected and compacted, and for this process a name is still required. It is the albuminous substances incorporated in Castilla rubber which continue to ferment and putrefy, or otherwise contribute to the deterioration of the rubber, both crude and manufactured. In other words, it is the albumens rather than the resins which determine the inferiority of rubber, and the amount of resin contained in the latex of adult Castilla trees is held to be "entirely innocuous" and "absolutely unobjectionable," Dr. Weber continues:

"I am quite aware that now and then all sorts of sinister actions are ascribed to the presence of resins in India rubber, but there is not the least particle of evidence to show that they are intrinsically detrimental. As a matter of fact, in the manufacture of quite a number of rubber goods, resins are deliberately added to the mixings."†

Other Methods of Coagulation.—The traditional method of treating Para rubber in Brazil is to spread it in thin layers on wooden paddles, which are held over burning palm nuts. The highest grades of commercial rubber have been produced in this way, but the process is too slow, laborious, and disagreeable. There seems, however, to be ground for a suspicion that some constituent of the smoke which is incorporated into the rubber may have a beneficial effect upon its mechanical properties, and the previously cited adverse opinion upon the pure but unsmoked Hevea rubber from the East Indies seems to give further warrant for such a notion. The experiment of smoking Castilla rubber has been tried at La Zacualpa, but the result was a hopelessly sticky mass. The difference of behavior is, however, more likely to be due to differences in the latex than to differences in the rubber itself.

It is not to be overlooked that, while the high percentage of albuminous impurities in Castilla rubber has rendered the price lower and the removal of them should increase the price, yet it will reduce the quantity of the marketable product and will thus not be an unmixed advantage. All the methods of coagulation now in use bring about the incorporation with the rubber of a large amount of the albuminous substances of the latex. Dr. Weber claims that if none of the albumens are left out they will constitute over 25 per cent of the solid product and adds:

"The native rubber collectors prepare the rubber from the latex in such a way that at least part of the aqueous vehicle of the latex is drained away before coagulation takes place, and consequently we never find a Central American rubber (crude) which contains as much as the above-stated quantity (25 per cent of albuminous matter), but lots containing from 9 to 13 per cent are quite common."*

The meaning of this sentence is not obvious, and it becomes still less so if we read it in connection with one which follows a little later.

"Therefore, whenever we coagulate the rubber, we can only do so by coagulating it in conjunction with the albumen present, and we have at once a product possessing all the irremediable drawbacks which above we discussed at some length."

None of the native methods of coagulation enumerated by Dr. Weber shows any provision for eliminating any part of the albumen. There is certainly nothing of this kind in connection with scrap rubber, into which all the solid constituents of the milk are simply dried down and little escapes except by evaporation, and yet scrap rubber is commonly deemed of good quality. In coagulation by the acid or alkaline juices of plants or by soap, salt, or alum, or by the boiling of the juice, the only materials which escape are those which do not coagulate, so that it is difficult to avoid the inference that the percentage of albuminous matter is not constant or that it has been incorrectly determined.

1. Spreading latex on Calathea leaf.

2. Pressing two coated leaves together.

3. Pulling the leaf from the rubber.

4. Finished sample of rubber.

NATIVE METHOD OF COAGULATING LATEX.

* Parkin, Annals of Botany, 14:198, 1900.

* Parkin, Annals of Botany, 14:199-200, 1900.
† Tropical Agriculturist, 22:444, January, 1903.

* Tropical Agriculturist, 22:442, January, 1903.

At La Zacualpa was witnessed still another method of coagulation by which all the non-volatile constituents of the latex are retained. The latex is spread in a thin coating upon the large banana-like leaves of a species of Calathea, laid out on the hot, bare ground in the open sun. This exposure to heat, light, and air turns the milk dark with great rapidity, and in a few minutes it has become firm enough to permit a second layer to be spread on. Subsequently two of the leaves have their rubber-covered faces pressed together by being trodden upon, and the rubber adheres to form a single leaf-like sheet from which the leaves themselves are easily stripped away. Three stages of the process and the finished product are illustrated.

Coagulation of Scrap Rubber.—Whether due to a varietal difference in the trees or to climatic or other differences of the external conditions, it seems to be a general fact that on the more continuously humid eastern slope of Central America the milk of Castilla does not run from the trees in quantities which can be collected and treated by improved methods of coagulation, but hardens in the cuts made by the rubber gatherer, who does not carry home the milk but returns in a day or two to pull out the dried "scraps," as rubber obtained in this way is called in the trade. As both the quality and the price of scrap rubber are satisfactory, the chief objection to this method of harvesting is the greater number of cuts in the tree and the greater amount of labor necessary to collect it, though the latter objection is somewhat counterbalanced by avoiding the work of coagulation. The principal point is the amount obtainable, and this depends upon the question of climates and varieties rather than upon that of coagulation. According to Prof. H. Pittier, six pounds of scrap rubber are sometimes taken from a single wild tree in Costa Rica; but while this amount is considerable it is much less than that claimed by Koschny for the same country.

ULTRA-VIOLET LIGHT AND THE ELECTRIC DISCHARGE.*

By WALTER J. TURNEY.

THE following experiments show how, with simple apparatus, a phenomenon of the electric spark, not

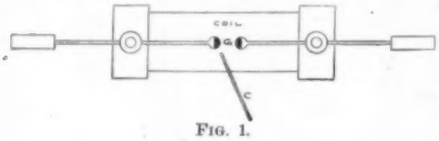


FIG. 1.

generally known but of no small scientific importance, may be demonstrated.

Fig. 1 represents a Ruhmkorff coil whose terminals, which are fitted with knobs, are adjusted so that sparking just fails to take place at the gap *G*. On setting the coil in action, and presenting a conductor *C* to the shaded portion of either knob, vigorous sparking will begin at *G*, ceasing, however, on the withdrawal of the conductor. Strange to say, a non-conductor such as glass or paraffine wax may be substituted for the conductor, with similar results. A discharge may also be started between two points in this manner, though the effect is not so pronounced as when knobs are used. In this experiment as in those hereinafter described, the knobs must be highly polished to obtain the best results. A one-half-inch coil was used in these experiments.

With a view to determining the cause of the above phenomenon, the writer devised the apparatus shown in Fig. 2. A piece of bare wire *W*, about four inches in length, is bent into the form indicated, and attached to that knob of the coil from which the longest spark can be drawn on presentation of a conductor, the terminals of the coil being adjusted as in the first experiment. If the conductor *C* be now presented to the end *T* of the wire, continuous sparking will begin at the gap *G*. On placing a plate *P*, which may be of cardboard, glass, mica, metal, or almost any material at hand, in such a position that *G* is invisible from *T*, sparking will cease, commencing again on removing the plate. If, however, in place of *P*, a piece of rock-crystal, gypsum (selenite), rock-salt, or alum be introduced, sparking will not be stopped. The rock-crystal and rock-salt used by the writer were about three-quarters of an inch thick. The crystals should

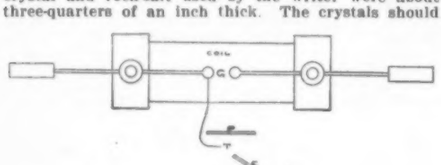


FIG. 2.

be cleaned before using. While the effect will be greatest when the conductor is brought near enough to *T* to draw sparks from the latter, it may also be produced though the conductor, especially if it be pointed, is several times too far from *T* for this purpose. In this case, however, a faint brush discharge is observable in the dark, between the two. It is best to scrape clean the terminal of the wire and the end of the conductor presented to it before the experiment. As in the first experiment, a non-conductor may be substituted for the conductor, with results which, while not so pronounced, are very striking.

If the wire is bent as in Fig. 3, so that the gap *G* is hid from *T* by one of the knobs, no sparking will take place at *G*, when the conductor is presented to *T*. But on bringing a mirror *M* into such a position that *G* can be seen from *T*, sparking will begin.

In Fig. 4 the wire is arranged as in the second experiment. A square prism of rock-salt *S*, say three-quarter inches on a side, in which form it may be obtained at small cost from a mineralogist, is inserted between *T* and *G*, being first turned so that one of its faces is perpendicular to the dotted line from *T* to *G*. On approaching the conductor to *T*, vigorous sparking will begin at *G*. If the rock-salt is now turned as shown in the diagram, the vigor of the sparking will be diminished, though any action proceeding from *T* in a straight line to *G*, would now have less distance to traverse through the rock-salt than before.

From the experiments above described, their probable explanation may be deduced as follows. It is evident that some action proceeding from *T*, starts the sparking at *G*. The second experiment shows that objects opaque to light are also opaque to it. The third and fourth experiments demonstrate that it may be reflected and refracted in the same manner as light.

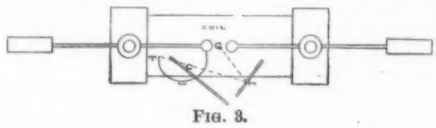


FIG. 3.

We are therefore justified in concluding the action to be due to some form of light. But that it is not ordinary light is shown in the second experiment, where glass and mica are found to be opaque to it. The phenomenon must therefore be produced either by the infra-red (heat rays) or the ultra-violet light. That it is not the former may be easily shown by substituting for the source of the action some more powerful emitter of heat rays, such as the glowing end of a match that has just been extinguished; in which case no effect will be produced. We may therefore consider the effect to be one of ultra-violet light.

The apparatus used in the above experiments is a simplification of that with which Heinrich Hertz discovered and investigated this phenomenon. A description of the apparatus used by Hertz may be found in his book on "Electric Waves," where a complete account of his researches on this subject may also be found. Other investigators have found that the negative knob of the coil is alone affected by the ultra-violet rays; also that many metals lose a negative charge of electricity when exposed to the light, though not a positive one. The peroxides when immersed in hydrogen, are, however, an exception to this rule, losing a positive charge. The loss of charge is retarded by a strong magnetic field. It has also been found that freshly cleaned zinc becomes positively electrified, when exposed to the rays.

The starting of sparking between the knobs of a coil, and the loss of charge of an electrified conductor by the ultra-violet light, may be explained either on the theory that disintegration is effected at the surface of the conductor or negative knob of the coil, during which charged particles of metal and metallic vapor are liberated; or that films of gas existing on either are decomposed and charged ions of gas thrown off. According to either hypothesis the resistance between the knobs of the coil would be decreased by the light, thus facilitating the discharge. Their application to the electrified conductor is, evi-

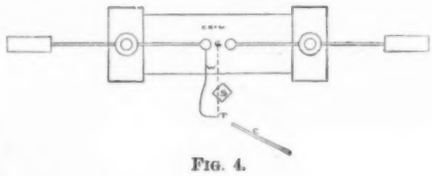


FIG. 4.

dently, that the metallic particles or ions of gas carry away the charge.

It seems remarkable that discoveries so important as those above described should have as yet been put to no practical use. The writer has found it possible to work a wireless telegraph receiver by starting and stopping sparking between the knobs of the coil used as transmitter, with the ultra-violet rays.

No doubt many interested in science are deterred from studying direct from nature through their own experiments, because they think the apparatus necessary would be both complicated and expensive. But it is a fact that many of the most important truths of science may be experimentally demonstrated with simple apparatus and at small cost.

New York City.

THE MARVELOUS OBELISK OF MONT PELE.*

By EDMUND OTIS HOVEY.

BY far the most remarkable change that has taken place in Mont Pelé since the present series of eruptions began in April, 1902, is the growth and variation in altitude and form of the cone of eruption and the enormous spine or obelisk surmounting it. These have been noticed at greater or less length by the author, by Prof. Heilprin, Prof. Lacroix, and Prof. Sapper. It is proposed, therefore, in this brief sketch to bring to the attention of the readers of the SCIENTIFIC AMERICAN SUPPLEMENT some of the most important features of this strange development in mountain making.

Prior to the beginning of the present series of eruptions, the mountain was characterized by a great crater about a half a mile across and 1,000 to 2,000 feet deep below the level of the crater-rim. On the southwest side the crater-rim was breached to the base by a great gash which was continued into the gorge of the Rivière Blanche. Within the great crater lay the small crater-lake known as l'Etang Sec, and from several openings around this lake began the uprush of ejecta which has proved of such moment in the history of the island. A cone or series of cones began forming at once, as is shown by the accounts of several persons who visited the crater late in April and found cones of "cinders" built up about two vents west of l'Etang Sec and one to the eastward thereof.

The first studies of the mountain in May and June, 1902, gave the geologists no hint that the new cone of eruption within the great crater was anything but a rapidly growing "cinder" cone. Masses of rock projected at times from the sides or top of the new cone, but they disappeared again, and partly concealed as they were by the constantly shifting steam and atmospheric clouds, their true significance was not apprehended. In the latter part of October, 1902, the clouds cleared away from the top of the mountain sufficiently to enable Prof. Lacroix to determine accurately the character of the new cone. The tip of the toothlike projection above the new top of the mountain was about 295 feet above the rim of the old crater. The new feature was seen to be an obelisk of "solid" rock, not débris, and Lacroix advanced the idea that Pelé now was to be classed as a *cumulo-volcano*, a theory which his subsequent observations and those of his colleague Giraud, and of Sapper, Heilprin, and the author have fully confirmed.

Since this time the prominent spine or tooth has grown wonderfully and varied greatly in size and form from time to time. Occasionally there has been a loss of several or even many meters from the top, but the loss has always been recovered within a short time. On November 8, the 100-meter-high tooth with its almost vertical walls, the northeastern side of which looked "polished," was the absorbing feature in the view of the new cone from the crater rim beside Morne Lacroix; this tooth was only beginning to be noticeable three weeks before. At the end of March 1903, the French Commission determined the apex of the spine to be 1,568 meters (5,143 feet) above the sea or 338 meters (1,109 feet) higher than the remains of Morne Lacroix, but in the meantime there had been a period when the cone had reached nearly this maximum and had fallen again. After each considerable explosion the cone is seen to have changed more or less. Portions have fallen off and the altitude has usually diminished. One of the heaviest eruptions which have occurred since August, 1902, took place at 6:12 P. M., March 26, 1903. The next morning Captain Perney, at Morne des Cadets, found that the apex of the spine was 25 meters (82 feet) lower than before the outburst. In April the official bulletins of the commission, from which these and the following figures are compiled, record a further loss of 6 or 7 meters. In the early part of May, there was a recovery of a portion of the lost altitude, but during the night of the 30th, 50 meters of height disappeared from the spine. The feeble activity of June restored 25 meters of the loss, but during July and the first half of August the loss was continuous, so that the net diminution in altitude of the apex of the needle was not less than 175 meters (574 feet). On August 18 the observers noted that the dome or main mass of the new cone was rising bodily in connection with a marked increase in the activity of the volcano. By the end of the month the dome had risen 141 meters (462 feet), but during September the movement was variable, resulting in a net loss of 6 meters (20 feet). The spine, which was stationary during the latter part of August and the early part of September, rose 20 meters (65 feet) between the 9th and the 13th of September, a gain which was lost again on the night of the 16th.

The rim of the crater is irregular in height, rising from 1,070 meters (3,510 feet) beside the head of the Rivière Blanche gorge to 1,210 meters (3,969 feet) beside the basin of the Lac des Palmistes, and it culminates in the remains of the rock-mass of Morne Lacroix, which the author determined at 1,230 meters (4,034 feet) as the average of two readings of his aneroid barometer taken five hours apart on March 21, 1903. North of Morne Lacroix the altitude of the rim decreases gradually till the middle point of the northern rim is reached, where the author got a reading of 1,130 meters (3,706 feet) beside a precipice which prevented further progress westward. The rim here dropped 10 meters, perhaps, but soon rose again, and the western edge of the crater is essentially horizontal at an elevation (judging from the heights above Prêcheur) of about 1,150 meters (3,772 feet) till the remains of Petit Bonhomme are reached. This rock-mass, the only one besides Morne Lacroix on the edge of the crater, overhangs the northern side of the gorge of the Blanche (i. e., the great gash). It seems to have lost some of its altitude and mass since June, 1902; then its altitude was judged by Curtis and the author to be about 4,000 feet (1,220 meters) while in March, 1903, it could hardly have exceeded 1,180 meters (3,870 feet).

The crater is wider than it was in June, 1902, the increase being toward the east, south, and southwest. On the east and south the tuff walls are almost if not quite vertical. Numerous landslides have occurred here, and in March, 1903, it was necessary to exercise great caution in traversing the rim on account of the cracked condition of the agglomerate. The V-shaped gash in the southwestern rim is wider, or rather the southern side of it has been cut away, but the débris from the new cone nearly fills it.

The new cone with the great spine is not central within the old crater. The most important of the openings concerned in the present series of eruptions were on the west side of the old crater-lake, l'Etang Sec, so that the new cone has been built up northwest of the center of the old crater. The spine rises from the northeastern quarter of the new cone. This has resulted in the complete filling of the northwestern quarter of the crater, making the slope of the new cone on the west and northwest sides continuous or nearly continuous with the exterior of the old crater-rim. On the northern, eastern and southern sides, between the new cone and the crater-rim there is a shallow spiral valley which debouches into the gorge of the Rivière Blanche on the southwest. The deepest part of this valley seems to be beneath the ruins of Morne Lacroix, and is estimated to be about two hun-

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

* In May, 1902, the author was sent by the American Museum of Natural History to study the eruptions on Martinique and St. Vincent. In February, 1903, the same institution sent the author on a second expedition to the region to note what changes had taken place in the volcanoes since the previous visit, make additional observations under the more favorable conditions incident to the dry season, and extend his studies to the other recent volcanoes of the Caribbean chain.

dred feet deep below the old crater-rim. It seemed much deeper (500 to 800 feet) during June, 1902. On the southwest the new cone slopes continuously into the débris filling the gorge of the Blanche.

The new cone is a composite affair made up of fragmental ejecta from the vents, lava which has welled up or been pushed up from below, and masses which have fallen or been blown off from the latter. The spine or tooth consists of "solid" rock which seems to have been pushed up bodily into its present position, and to be maintained there, somewhat like the stopper in a bottle, by friction against the sides of the neck and by the expansive forces underneath. The shape of the spine, with its sides forming angles of 75, 87, and even 90 deg. with the horizontal, is a strong argument against the theory that it has been formed by ejected blocks or bombs which were sufficiently pasty to stick together on falling, and in favor of the "stopper" theory. Furthermore, the northeast side of the spine presents a fairly smooth, vertically grooved surface, as if it had been slickensided by friction against the side of the conduit during its ascent. The great and sudden changes in the altitude of the spine with reference to the rest of the cone point in the same direction.

Great ribs or dikes of lava extend to the sides of the new cone from the base of the spine on the northeast, southeast, south, and west. The lofty tooth or spine is rifted and fissured in every direction, and portions of it are constantly falling from its sides. Some of the vertical fissures are very prominent on the east side and evidently connect with fluid lava beneath, for they have been observed to become luminous at night from below upward, and the light has died out gradually from above downward.

The northeast side of the spine is strikingly different in appearance from the southwest side thereof. The former shows a nearly smooth surface which is almost polished in its effect. In the light of the rising sun the spine looks like an enormous white monument rising above the mountain. The true color of the northeast side of the spine, however, is more a reddish brown with a whitish incrustation over a part of it. The southwest side of the spine constantly shows fresh surfaces on account of the portions falling off, and this side is gray or reddish gray in color.

No one can say yet exactly what the nature of the spine is, but there seems to be no room for doubt that it is largely pumiceous in texture, judging from its being so rifted, from the readiness with which the masses break off from it and especially from the abundance of pumice in the new material filling the gorge of the Rivière Blanche. The surface presented by the northeast side is probably solid and glassy through different conditions of cooling. The bombs, which lie in profusion over the basin of the Lac des Palmistes and other parts of the crater rim, are of all kinds from wholly pumiceous with a thin, densely vitreous crust to those which are mostly lithoidal in texture.

The author found one true bomb on the edge of this basin which was fresh pumice in the interior with the usual fresh, densely vitreous crust about an inch in thickness, but a part of the exterior portion of the mass was formed by a lump of oxidized agglomerate. Evidently this mass had been in contact with the walls of the conduit through the old tuff beds of the volcano. Usually one can readily distinguish between bombs which are true bread-crust bombs in the sense that they are portions of the fresh magma which have been blown into the air, where they consolidated, and those which consist of fragments of ancient lava beds which have been broken off and recently reheated to a molten or plastic condition and then ejected. The latter often show characteristic surfaces of conchoidal fracture which are not observed on the former, and they are more lithoidal in texture than the former. Angular fragments of lithoidal lava, ¼ to ½ inch across, coat parts of the crater rim near the Lac des Palmistes basin, apparently blown there from the new cone.

There is now no central opening or pit-like depression in the top of the new cone corresponding to the general idea of a crater. The incomplete glimpses of the active cone obtained in June, 1902, seemed to the author to indicate the existence at that time of a true crater in its top. The growth of the spine has destroyed this crater, if it ever had any long-continued existence. Steam issues with vigor from all parts of the cone, but especially from the top and from the southeastern portion, but not from the spine. Minor explosions occur from the southwestern side at an elevation of apparently about 4,000 feet (1,220 meters) above the sea, and from the northwestern side at a somewhat greater elevation. Heavy outbursts have taken place on December 16, 1902, January 25, 1903, and March 26, 1903, with less important ones on other dates, from the southwest side of the cone near the base of the spine or from 4,400 to 4,500 feet (about 1,375 meters) above the sea. There is no one definite conduit through the cone or spine itself, to the exclusion of others.

There was great increase in the activity of Pelé during the early part of September, and the occurrence of a heavy eruption was feared. September 12 and 19 the eruptive blasts descended the eastern side of the mountain as far as the devastation in May, 1902, extended, an exhibition of dangerous energy. On September 15 the eruption cloud rose vertically to the exceptional altitude of 7,000 meters (23,000 feet) above the sea. By the end of the month the renewed activity had expended its force and the volcano was in a less threatening condition.

In spite of the fresh lava forming the spine, the dikes in the new cone, and the numberless bombs, no *stream* of molten lava has issued from Pelé during the present series of eruptions. This phenomenon is probably due to the great excess of water-vapor (steam) connected with the eruptions, as compared with the amount of liquid lava rising in the conduit or series of conduits. The excess of water vapor combined with the viscidity of the lava has caused the outbursts to be violently explosive without permitting the quiet exudation of liquid rock in sufficient quantities to form streams.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Room for American Manufacturers in Germany.—Autos.—Small automobiles or runabouts of American make, of from 6 to 10 horse power, would, I think, have a good sale in this district. So far, only one American company has even asked for information as to the real class of goods wanted—though some fifty have sent English catalogues, which are worse than useless, as the people will not even look at them. What is wanted is a light machine, easily worked—not a complicated piece of machinery—with good brake power, as it is very hilly here, and above all a machine that is not too expensive. I should advise the opening of a small depot either here or in some neighboring city where the goods can be shown and explained and where duplicate parts can be quickly and easily had. This latter is a very important matter, as German makers do not care to repair foreign (especially American) machines if they can possibly help it.

Rubber Boots and Shoes.—For rubber boots and shoes I know no better market than this, yet it seems to be totally neglected by our manufacturers. We now have to send to Berlin for everything of that kind, which causes extra expense and no chance to pick out the kind of rubber wanted.

Gas Cooking Stoves.—I think there is no place in the world where so primitive a gas stove sells for so much money as in Coburg. It would pay any of our well-known makers to send a few samples to the Coburg City Gas Works on commission and thus introduce something to the local market worth having.

Fruits.—While some kinds of California and other American dried and evaporated fruits are for sale here, the real good article is not to be had, and consequently we are often told that our fruits are not as high class as the Metz and other German brands. Our large exporting houses can rest assured that much better markets are to be had in the middle and southern parts of the empire than in Hamburg and Berlin, especially for this class of goods, as the people are great preserved-fruit eaters and the local fruits are neither extra good nor cheap. The best way to send them is in half-pound glasses or tins, with labels in German explaining just how the fruits are to be treated or served.

Hardware and Agricultural Implements.—This is a branch that has been somewhat pushed in a business-like manner, with the result that it has paid well. While on every hand one can see evidences of the work accomplished, I think that very much more could be done if proper catalogues, diagrams, and explanations, in the German language, were sent around into the towns and villages.

Coal.—Since my last year's report (1902) nothing seems to have been done to promote the sale of this article. The samples that have been tried here have given most satisfactory results, but the business has been allowed to drop without a single effort to keep even the ground won by the favorable trials at different porcelain factories. The British seem to see the business that is to be done in coal in Germany, as the following statement shows: Imports into Germany of British coal during the first six months of 1901, 1902, and 1903 were 2,356,980, 2,289,259, and 2,444,688 tons, respectively.

Horses.—There has been quite a good demand for useful carriage, heavy draft, and a few selected saddle horses in this market but only a few American horses have been for sale. Owing to the stony and hilly nature of the country, eastern horses do very well here, but western animals' hoofs go to pieces too quickly. There is quite an opening for very small ponies to take the place of dogs as used at present in pulling butcher, milk, and other carts.

Small Chemical Fire Engines.—A good agent for an inexpensive but reliable class of these goods, if sent through the smaller towns, etc., giving practical exhibitions of his apparatus, would, I know, do a good business.—Oliver J. D. Hughes, Consul-General at Coburg, Germany.

Subsidizing Hungarian Flax and Hemp Production.—The following notes have been translated by the Bureau of Statistics, Department of Commerce and Labor, from Das Handels Museum, the official organ of Austria:

"The Hungarian Minister of Agriculture shows a lively interest in the movement among Hungarian farmers favoring a more intensive system for producing hemp and flax in the Hungarian fields. He is exercising the power vested in him by the legislature to encourage the industrial manipulation of hemp and flax by affording State aid to all those meeting the requirements or stipulations provided by the acts making the grants and giving him power. The aid is afforded or based upon the following conditions:

"1. Societies, manufacturers, or corporations who erect a hemp and flax mill of large capacity and fully equipped, and who will bind themselves to take, as far as possible, a certain quantity of raw material (hemp and flax) from small farmers at a fixed price, may obtain a loan of fully 50 per cent of the building and equipment expenses up to a maximum of 75,000 crowns ($15,225). The repayment is to begin in the eleventh year after the establishment of the concern and is to be made in partial payments during fifteen years. Thus the loan lasts practically for twenty-five years.

"2. Associations that put up small mills may get State aid up to a maximum of 50,000 crowns ($10,100); not repayable, if a majority of their shares are in the hands of small farmers.

"3. Village communities and small agricultural societies may receive, upon erecting a hemp-steeping shed, a non-repayable State stipend up to 5,000 crowns ($1,010), provided they add the necessary auxiliaries, such as fields, barns, and waterworks.

"4. In cases where within twenty-five years after the erection of the works, the establishment should fail to go on or should be used for other purposes than those for which the subsidy was paid, the loan will have to be paid back to the government.

"5. The State loans and the non-repayable subsidies will not be paid out before the buildings have been put up and have been inspected by or for the government.

"6. Except where permission has been granted to do so, only Hungarian products may be used in these subsidized factories.

"7. The establishments supported by the State will be under State control and inspection."

Congress of German Electricians.—Beginning with June 7, 1903, a three days' congress of the German Society of Electricians was held in Mannheim. The meetings were attended by about 300 electrical engineers from all parts of the empire.

Papers were read on a variety of topics pertaining to electrical engineering, especially as applied to street railway construction, electric lighting, etc. Among those who presented papers were Privy Councilor Prof. Arnold, of Carlsruhe; Prof. Görges, of Dresden; and Baron von Gaisberg, of Hamburg.

At this meeting, as at similar meetings in Germany, that which first attracts the attention of the observer is the active part taken by teachers from the technical and other schools in what might be regarded the purely practical side of the subject.

Thus, in this particular case the discussions led into the construction of street railways, installation of light and power plants, etc. Among those who took a leading part in these discussions were teachers and professional men.

No opinion is ventured as to whether, upon the whole, a science such as that of electricity, mining, architecture, etc., progresses more rapidly if left mainly to what may be termed the self-made unprofessional engineer or if left more under professional or academic control. The German manufacturer or railway builder would doubtless answer the question in favor of the professionally trained expert.

The conditions existing in the two countries being in many respects different, the advancement made in electrical engineering, for example, affords no complete answer to the question.

It would be conceded on both sides of the ocean that in the more difficult field of chemical manufacture the professionally trained chemist has been indispensable.—H. W. Harris, Consul at Mannheim, Germany.

British vs German Trade in Russia.—The British consul-general at St. Petersburg, in his report for the year 1902, again adverts to the fact that Germany is gradually crowding out England from the Russian markets. He counsels his countrymen to adopt German methods in seeking foreign trade, viz., sending agents and commercial travelers to Russia who speak the Russian and German languages. He also advises the establishment of sample warerooms for British goods in Russian trade centers and that the utmost care be taken in packing for export. In 1902 Germany exported goods valued at $104,905,194 to Russia, $1,415,000 in excess of the exports for previous year; whereas British exports only amounted to $51,348,388, $2,075,000 less than the exports of 1901.—Simon W. Hanauer, Deputy Consul-General, Frankfort, Germany.

German Freight Cars.—The carrying capacity of the average German freight car is from 10 to 15 metric tons. Recently the Vereinigte Königs und Laurahütte Aktiengesellschaft für Bergbau und Hüttenbetrieb one of the greatest manufacturing and industrial establishments of the empire, received an order from the Prussian state railways for 200 freight cars, each of 20 metric tons capacity. The railroad authorities are now discussing whether it will be wise to still further increase the car capacity. While they are busy investigating the subject and gathering statistics relating thereto, it has been decided to have a few cars, each of 30 tons carrying capacity, constructed, in order to make a practical test as well.—Brainard H. Warner, Jr., Consul, Leipzig.

Biscuit Factory in Barbados.—Consul Macallister, writing from Barbados under date of August 25, 1903, reports the establishment of a large biscuit factory at Barbados. It is expected to cut off the importation of biscuits from the United States, which amounted to about 3,842,360 pounds per annum, valued at from $120,000 to $125,000. Flour from the United States, at least to a certain extent, will take the place of the biscuits.

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Other Reports can be obtained by applying to the Department of Commerce and Labor, Washington, D. C.

ELECTRICAL NOTES.

It is reported in the German press that successful experiments have been made in various forests of France in cutting trees by means of electricity. A platinum wire is heated to a white heat by an electric current and used like a saw. In this manner the tree is felled much easier and quicker than in the old way; no sawdust is produced, and the slight carbonization caused by the hot wire acts as a preservative of the wood. The new method is said to require only one-eighth of the time consumed by the old sawing process.

A French company claims to have got over the necessity for using platinum in the manufacture of incandescent lamps. The reason for the use of platinum is that its coefficient of expansion is the same as that of glass, and, therefore, changes of temperature do not cause cracking. A further reason is that when platinum is fused into the glass, the latter adheres to the platinum as though cemented. While other metals, particularly some alloys, such as nickel steel, have been found which have a coefficient of expansion equal to that of glass, none of them has the property of forming a tight joint when fused in. To get over this difficulty a French company, which manufactures incandescent lamps, has discovered a cement which enables it to secure a tight joint around the leading-in wires without its being necessary to use platinum. This cement is said to be unaffected by air or ordinary temperatures.

Birkeland's electromagnetic gun was described in an improved form in an address recently delivered in Copenhagen. Its principle, as is known, consists in attracting an iron core into the interior of a solenoid and in projecting it out of the tube on the opposite side. This is insured with a comparatively low consumption of energy, and practically without any sparking, by exposing the coils of the solenoid to heavy overloads during small fractions of a second only, by means of an automatical switching device. The projectile is saturated with magnetism by means of a coil fed from an independent source of current; a special motor, the axle of which is fixed to the back part of the projectile, serves to rotate the latter before it commences its run. The modified type of projectile consists in solenoids, the use of which is particularly suitable when the internal resistance of the source is low. Moreover, they are susceptible of giving much higher efficiencies, as the motive force may increase up to values sixteen times greater than that of iron projectiles.

Prof. Oliver W. Brown presented a paper before the Niagara Falls meeting of the American Electro-Chemical Society last month, in which he discussed the efficiency of the nickel-plating tank. To study the problem the author has determined the signal potentials of anode and cathode separately by means of a standard electrode. His results show that electrolytic nickel anodes corrode very poorly as compared with cast nickel anodes; pure rolled anodes are no better than electrolytic. The cathode efficiency is affected to a marked degree by the anode efficiency. The satisfactory operation of a nickel-plating solution depends to a large extent on the character of the anode employed. The purest anode material is not the best; presence of copper is advantageous to a certain extent, and it is quite likely that certain other impurities which are usually present in cast nickel may be equally advantageous. The reason that cast nickel anodes show a superiority may be due to the impurities or to a different physical structure which gives rise to a great porosity and roughness of the surface, and thereby a greater actual surface area. The electroplater can obtain an efficiency of 90 per cent or more if cast anodes are used, with an anode density of about five amperes per square foot.

The Electrolysis of Water Vapor.—A paper on this subject was read by Mr. F. A. Lidbury, at the recent convention of the American Electrochemical Society, which tends to show that electrolysis in gases may be a more complex process than electrolysis in liquids, so far as relates to the quantities of matter decomposed. The conclusion is drawn that in the partial decomposition of water vapor by electrical discharges, the hydrogen and oxygen liberated tend to separate and to take up different positions in the tube, the hydrogen collecting at both anode and cathode, and the oxygen in the middle of the tube. This result is so anomalous by comparison with the action that takes place when discharges pass through water, instead of water vapor, that further experimental research should be directed to this matter. At first sight the result seems very improbable. In dealing with water vapor subjected to electric spark discharges, it has to be remembered that the heat of the discharge may be capable of decomposing the vapor into its constituent gases, and that complex results may occur when thermal dissociation is superposed upon electrolytic dissociation.

Semi-vitrified porcelain does not possess very great insulating properties, even if it is perfectly dry. On the contrary, when completely vitrified, a plate only 3 mm. thick is able to resist a tension of 40,000 volts. Porcelains of which the external appearance is equally good often possess very different insulating properties. The essential qualities of porcelain for electrical work are—(1) Resistivity to be as high as possible; (2) mechanical resistance to be sufficient for resisting tension exerted by the conductors and for withstanding violent shocks without fracture. Porcelains of which the resistivity is the highest contain a large quantity of silica proportionately to alumina. If the proportion of potash is increased and that of lime diminished, the result is that the material becomes friable and fragile; therefore the quantity of lime should only be reduced proportionately to the reduction of potash. About 20 per cent of lime is sufficient to give the qualities necessary for mechanical resistance; and it appears necessary that the proportion of silica should not be less than 6.2 parts to 1 part of alumina. In order to secure porcelain possessing adequate mechanical resistance it is necessary to observe the proportions of between 40 per cent of potash to 60 per cent of lime, and 80 per cent of potash to 20 per cent of lime.—L'Electricien.

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